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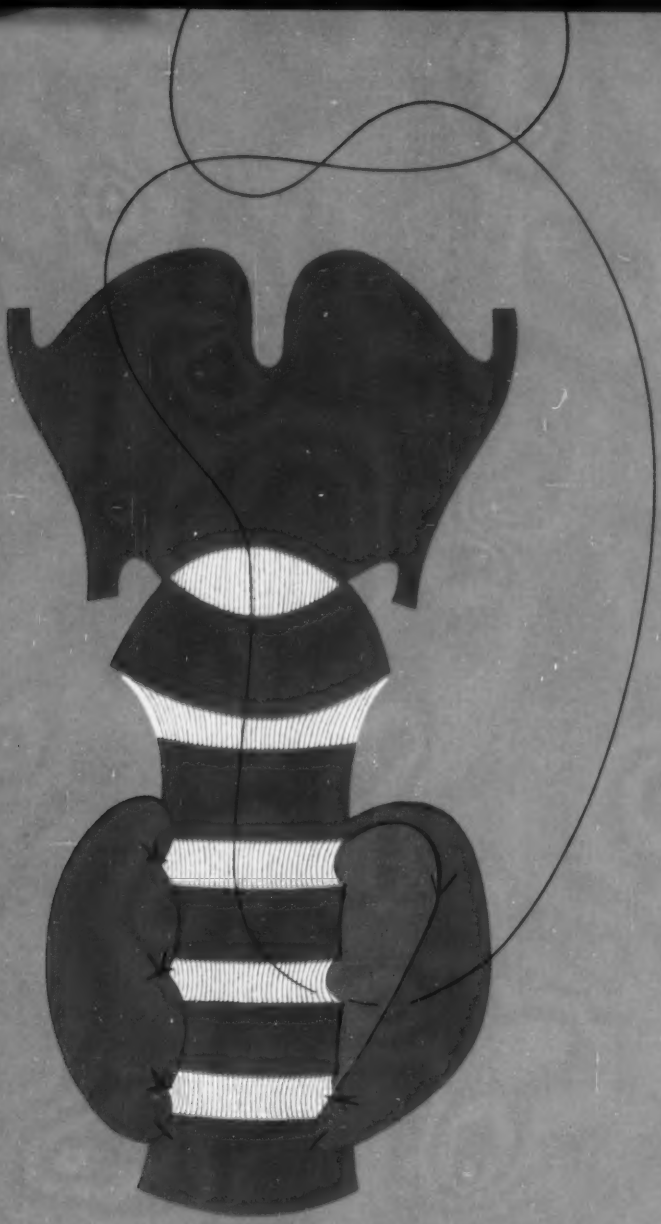

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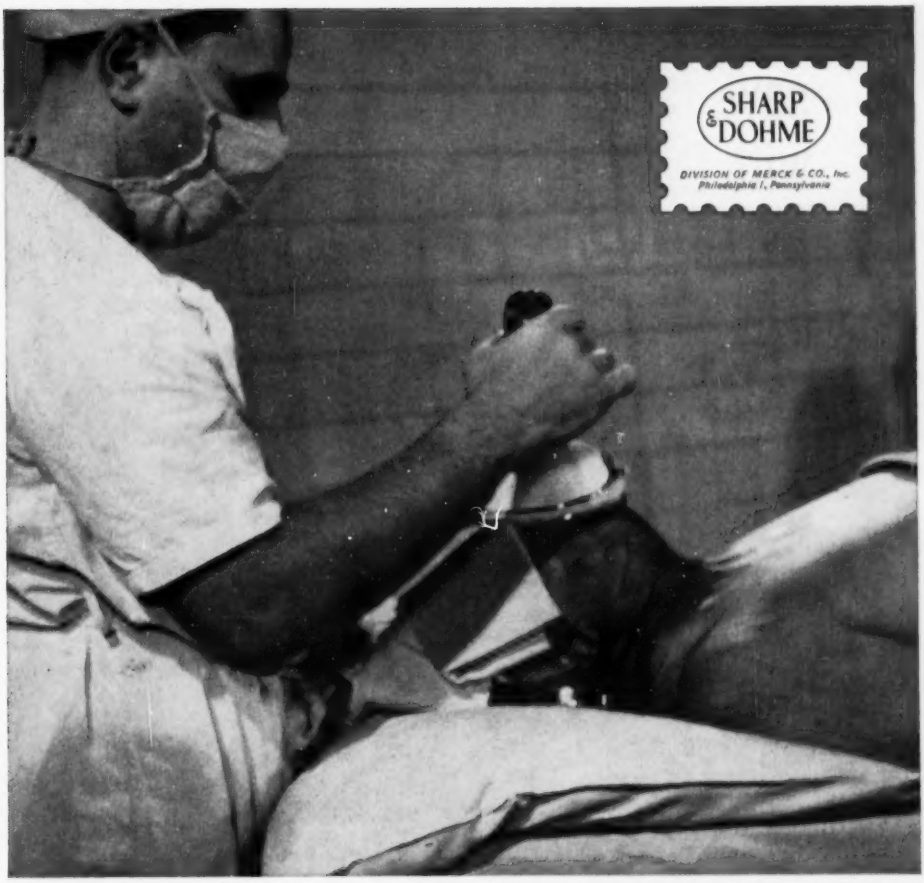

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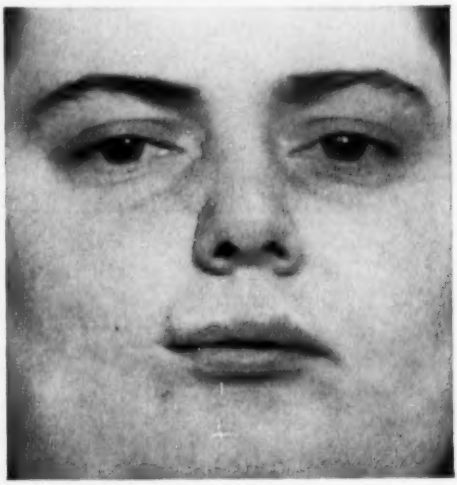

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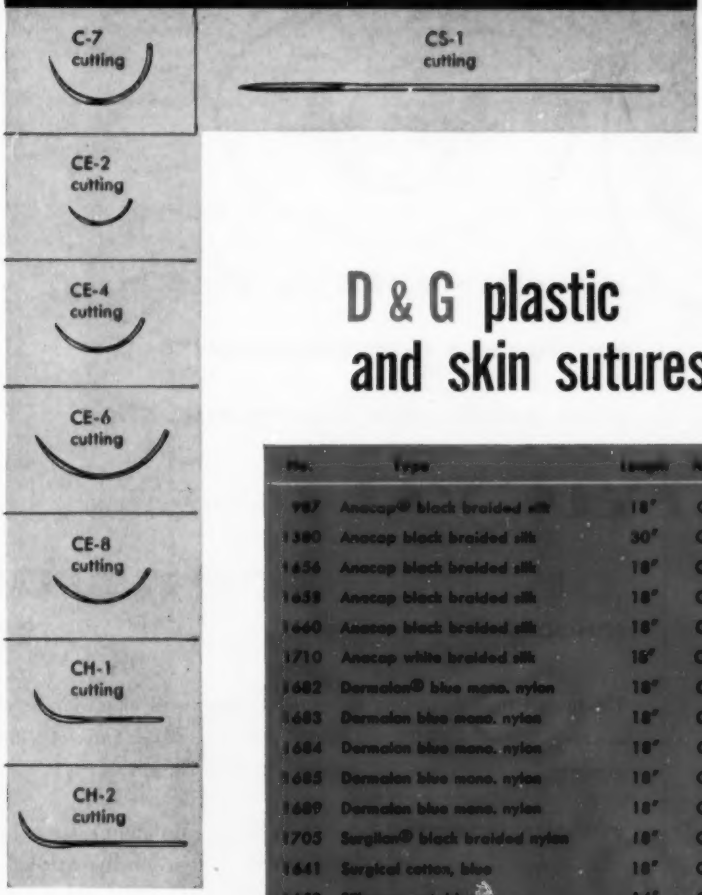

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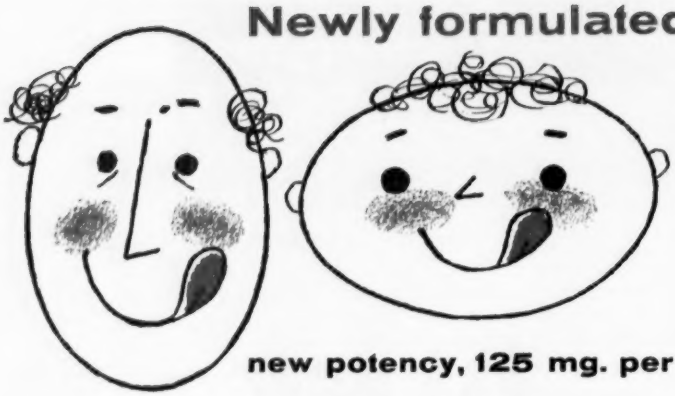

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VOLUME 69 OCTOBER 1954 NUMBER 4

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FOREWORD

DR. FREDERICK W. RANKIN, President of the American College of Surgeons (1953 to 1954), past President of the American Surgical Association (1948 to 1949), the American Medical Association (1942 to 1943), the Interstate Postgraduate Medical Assembly (1943), the Southeastern Surgical Congress

DR. FREDERICK W. RANKIN

(1938), and the Southern Surgical Association (1937), passed away on May 22 of this year after an extended illness.

In addition to the many honors which he had received, others were to have been given in May, 1954. At that time an honorary degree was to have been conferred on him by the Princess Royal, Chancellor of the University of Leeds, and at the time of the American College of Surgeons' sectional meeting in London, on May 17 to 19, 1954, he was to have been made an honorary Fellow of the Royal College of Surgeons.

Dr. Rankin had been in failing health for several months, but he had looked forward to attending these meetings in England.

In the earlier part of this year, a group of Dr. Rankin's friends, stimulated by his colleagues in the Department of Surgery of the University of Louisville School of Medicine, had planned to have a celebration in his honor at the Louisville General Hospital, at which time "the University auditorium was to have been dedicated to him." On this occasion it was planned that a half-day was to to be set aside for the presentation of papers on surgical subjects to be given by a few of his close friends. Arrangements were made for the meeting; the papers were written, but the meeting had to be postponed because of Dr. Rankin's illness.

The Editors of the A. M. A. ARCHIVES OF SURGERY are happy to cooperate with the members of the Department of Surgery of the University of Louisville School of Medicine, who arranged for the meeting, and the surgeons who were asked to present papers at the meeting, in publishing these papers in this issue of the A. M. A. ARCHIVES OF SURGERY (pp. 447-529) and with it a tribute to Dr. Rankin written by his close friend, Dr. Daniel Elkin. The members of the Editorial Board of this Journal would also like to pay tribute to a distinguished American surgeon whose career as a clinical surgeon and a military surgeon was one of outstanding achievement.

WALTMAN WALTERS, M.D.

FRED W. RANKIN, M.D.

DANIEL C. ELKIN, M.D.
ATLANTA

IT WOULD be idle to speculate or philosophize regarding the reasons why one man should achieve greatness and success where another with apparent equal opportunity does not. Such speculation can only lead to one of the greatest guessing games since the passing of Cock Robin.

On the other hand, I am old-fashioned enough to believe in heredity plus the leveling influences of environmental factors. In the case of Fred Rankin, one does not have to go back as far as the Darley Arabian to find a winner. He was sprung from solid Presbyterian stock of the John Calvin variety, the type that breeds high tolerance—at least for their own opinions. I am sure that many of the simple virtues of just and righteous dealing with men sprang from the lessons learned at his mother's knee.

You are, no doubt, acquainted with the advantages which he secured in college and in professional school. Probably of more importance in his early education was the fact that he at one time attended the Statesville Female College. I am told on good authority that his influence there was as disrupting to the faculty as it was later to the Office of the Surgeon General—so disrupting, in fact, that it became necessary to found in that village an academy for boys.* Here, under stern discipline, Fred learned the classics and the basic elements of sound education which were to prepare him and admit him to college at the age of fifteen.

It was but natural that he go to Davidson, stronghold of Calvinism, where he probably learned the prayer of its president. That eminent educator and divine was wont to supplicate his God, morning and night, like this: "O Lord, hear the prayer of Thy humble servant. Grant, O Lord, that I may always be right, for Thou knowest, in Thy infinite wisdom, that I will never change."

Having graduated with honors at Davidson and having attached to his watch chain a number of keys—including that of Phi Beta Kappa—he entered the University of Maryland, where he graduated in medicine in 1909. There followed a long period of internship and residency at the University of Maryland Hospital.

The additional investment of a year's work at St. John's College for a master's degree in English was undoubtedly part of a definite program, based on his often-expressed realization of the necessity of a broad education in the making of a doctor. One has but to refer to his many publications to understand the reasons for this step. His writings are always clear and to the point. Like Sir Winston, he believed the shortest word was usually the best.

*At this stage in his career there was considerable speculation among his teachers and members of his family as to whether he would end up in "Who's Who" or in the penitentiary.

There again followed a period of residency and an assistantship, this time at the Mayo Clinic, from 1916 to 1922, save for time out as commanding officer of a base hospital in World War I. Then came his professorship at Louisville, where he left a marked imprint as a teacher, administrator, and clinical investigator. He returned to the Mayo Clinic as head of one of the Surgical Sections for seven years, and was there afforded the opportunity to study a large number of patients and to perfect those operative techniques with which we associate his name.

And so it came about that his native ability, adorned by the honest sweat of hard work, gained him a reputation for what the world is pleased to call inspiration, but which men of achievement recognize as 90 per cent perspiration.

It was but natural that, having breathed a bit of Kentucky air—even though polluted with the miasmas of the Ohio River—he should return to Lexington to enjoy the full fruit of his training and experience in an atmosphere so congenial to his temperament.

Universities and societies honored him with degrees and citations, and the Army gave him its highest noncombatant award in the Distinguished Service Medal. I would not bore you with a recital of these lists of honors but only say that the facets of his mind and personality were as numerous and brilliant as those of the Hope diamond, that he had as many decorations as a Dorothy Draper ballroom, and as many degrees as a clinical thermometer.

Many stories have been told regarding his brisk wit and the charm of his conversation, so frequently punctuated by appropriate anecdote. Sometimes his darts were not without a barb. You will recall that during World War II, much publicity was given the fact that the mortality of wounded soldiers had been reduced from over 8%, as cited in World War I, to less than 4%. Concerning this remarkable achievement, both the Surgeon General and General Rankin were most voluble and pointed to it with pride, which was pardonable. During the Korean War the Surgeon General's office again pointed with pride to the further reduction in mortality. On one occasion when a propagandist of the Surgeon General's office was directing attention to this accomplishment, Dr. Rankin from the audience was heard to remark: "The next Surgeon General is going to find himself in a difficult position, because these fellows have already reduced the mortality below zero." This was said to have greatly entertained General Kirk and General Bliss, and they are alleged to have quoted it at times without giving due credit.

Dr. Rankin's papers, whether having to do with surgery or with the broader concepts of medical practice, cover a wide range. Although best known for his work on diseases of the gastrointestinal tract, you will find in his bibliography such a diversity of subject matter as diseases of the thyroid, the abdomen, and the extremities. He was once even so bold as to get in on my act and write a paper on the rarest of aneurysms, that of the internal mammary artery. I am sure he did not know what he was doing at the time, but he cured the patient, and it was this characteristic and this motto "Cure the patient" that made him the outstanding doctor of medicine that he was.

He never equivocated regarding right and wrong, nor did he respect anyone who did. In this he showed the obstinancy of the deaf and the intuition of the blind. His presidential address for the American College of Surgeons in 1953 expressed his credo of what the surgeon should be both in his own heart and in his relations to the

public and to the profession. These were not the babblings from the couch of a psychiatrist but the expressed feelings of one born to lead combined with the experience of a full life.

I would not say that he was intolerant of the ideas of others but, rather, impatient —impatient with incompetence, with inactivity, with speciousness, and with fraud.

Although his spotlight was trained on the surgical scene—focused, I might add, on himself as star—his encyclopedic mind was by no means limited to matters medical. He also concerned himself with the pedigrees of horses and the winners of games, and he had an elephantine memory for people and events.

It is not unusual that his friends in medicine should pay him honor. I know that numerous others outside our profession would do likewise. Because of his gregarious nature, these might well include college presidents, government officials, baseball players, prize fighters, actors, jockeys, and trainers.

He and I, and our families, were closely associated for more than two decades, so intimately that the home of each was as the home of the other. During the last two years of his life I saw much of him, and, although environed as he was by the ills of the flesh, he maintained the same buoyant spirit, the same versatile wit, and an even greater courage than in the days of less adversity. I have been the recipient of many favors from his hand, as have many others, from whom he neither expected nor asked anything in return.

We will never know a tougher, finer, gentler, or more companionable man.

This paper originated as a toast to follow the "Fred Rankin Day" dinner, Jan. 16, 1954, at Louisville, Ky. Because of Dr. Rankin's illness, the event never took place, and the toast is now presented with very little change, not as an elegy but in memoriam.

EFFECT OF NONSPECIFIC TRAUMA ON GASTRIC SECRETION AND ON QUIESCENT PEPTIC ULCER

JAMES C. DRYE, M.D.
ARTHUR M. SCHOEN, M.D.
AND
JAMES E. ROSS, B.S.
LOUISVILLE

IN A PREVIOUS paper, we reported a series of patients who, within a few days after trauma or surgery not related to the stomach, developed serious complications of their pre-existing peptic ulcers. Stimulated by these cases, we started a study of the relationship of such trauma and surgery to gastric secretion.

In our first paper,[1] we presented data showing that after duodenorrhaphy for acutely perforated duodenal ulcers, gastric secretion attained high concentrations of acids by 8 to 12 hours and maintained acid levels for the following 12 to 24 hours which were comparable to those found in a group of patients with active duodenal ulcers. No preoperative controls were available in these patients presented in the first paper.

In the present paper, we are presenting additional clinical and laboratory data on both ulcer and nonulcer patients with preoperative and postoperative control studies.

GENERAL OBSERVATIONS

Effect of Nonspecific Operations on Gastric Secretion of Patients Without Peptic Ulcers.—Eight patients were studied. All had operations not related to the stomach. In the preoperative period gastric secretions were obtained by continuous suction and were collected every 4 hours for 12 hours. In the postoperative period, the secretions were aspirated and samples collected every 4 hours for 48 hours. Acid was determined by pH meter as described in our previous paper (Table 1).

In the group of eight patients, one showed no acid either preoperatively or postoperatively; two showed no significant changes, and five showed definite to marked increases in the postoperative period. Of these five, two showed concentrations in the ulcer range. The average concentration of the group was definitely higher in the postoperative period than in the preoperative period (Table 3).

Effect of Nonspecific Operations on the Gastric Secretion of Patients with Peptic Ulcers.—Six patients were studied. These patients all had previous, known pep-

This is one of a group of papers originally prepared for a program which was to be presented at the University of Louisville to honor its now late Professor of Surgery, Fred W. Rankin.

From the Department of Surgery (Dr. Drye) and the Department of Medicine (Dr. Schoen), University of Louisville School of Medicine. Mr. Ross is a Student Research Scholar aided by a grant from the Baxter Laboratories, Inc.

TABLE 1.—*Free Hydrochloric Acid* in Nonulcer Patients*

	Preoperative Day			Postoperative Day											
Name	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
1) E. F.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2) J. M.	0	0	0	0	0	8.25	6.81	10.0	2.48	29.8	63.4	23.8	22.3	4.92	22.3
3) R. G.	0	0	16.10	0	0	17.4	39.5	52.3	44.3	44.3	37.7	41.4	41.4	60.8	60.8
4) E. P.	0	0	0	.50	2.43	25.8	16.8	61.8	1.92	.29	0	.12	0	.12	.....
5) M. E.	9.20	8.28	1.12	.89	.11	4.8	.67	1.0	4.92	.....	3.22	10.4	4.92	6.52	3.96
6) C. B. M.	0	0	0	0	0	.48	3.9	2.32	.61	.32	0	0	0	0	0
7) J. L.	1.42	1.88	0.78	3.98	5.95	2.43	.16	27.8	33.3	25.2	20.4	16.1	11.8	28.2	.....
8) B. M.	35.0	37.5	11.0	.28	28.3	25.3	.17	0	12.8	38.7	11.0	2.81	19.4	22.3	24.7
Total	45.62	47.66	29.00	5.65	36.79	84.46	68.01	155.22	100.33	138.61	135.72	94.63	99.82	122.86	111.76
Average	5.70	5.96	3.63	0.71	4.6	10.56	9.72	19.40	12.54	19.8	16.97	11.83	12.48	15.36	13.97

* Specimens collected at four-hour intervals; HCl concentrations expressed as milliequivalents per liter.

TABLE 2.—*Free Hydrochloric Acid* in Ulcer Patients*

	Preoperative Day			Postoperative Day											
Name	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
1) E. S.	9.10	.....	.....	30.50	67.00	35.00	10.40	10.153	10.153	16.50	16.00	16.80	17.70	36.10	48.10
2) M. E. Y.	16.00	7.93	7.93	0.00	0.21	8.72	5.23	27.00	42.80	45.90	28.50	58.10	58.10	43.5	.....
3) W. B. M.	0	0	0	0	0	0	21.30	17.80	10.25	11.50	.....	27.0	27.0	14.5	15.4
4) J. D. C.	19.1	.....	.....	0	19.1	57.8	.....	31.60	43.80	0.0	0.0	7.18	25.8	20.8	.....
5) J. W.	21.7	.....	.....	0	42.5	60.8	.....	.....	3.56	20.4	29.8	23.5	21.8	.....	.....
6) J. G.	0.263	0.395	25.7	53.8	58.2	64.0	45.5	53.80	61.00	67.0	67.0	67.0	100.	94.6	.....
Total	66.163	8.325	33.63	84.30	187.01	226.32	82.43	139.75	171.56	161.30	141.30	199.58	250.40	209.5	63.50
Average	11.027	4.162	11.21	14.05	31.17	37.72	20.60	27.95	28.59	26.88	28.26	33.27	41.70	41.9	31.75

* Specimens collected at four-hour intervals; HCl concentrations expressed as milliequivalents per liter.

tic ulcers. They all required surgery for diseases other than their ulcers. All showed marked increase in the postoperative hydrochloric acid concentration (Table 2). Three showed postoperative levels well within ulcer range (50 mEq. a liter or more). The average preoperative concentration, over a period of 12 hours, was 8.8 mEq. per liter, and the average postoperative concentration for a period of 48 hours was 30.32 mEq. a liter (Table 3).

Comparison of the response by the ulcer and nonulcer groups to the stress of operation as manifested by changes in gastric secretion is interesting. In general, both showed increases after operation. The increase in the ulcer group occurred more constantly and to a higher degree. The average acid secretion for the entire 48-hour period postoperatively is higher in the ulcer group (Table 3).

Clinical Observations.—In our first paper, we presented a series of five patients who developed severe complications after trauma or surgery. Two of these had sustained severe fractures and bled from preexisting ulcers. One bled, after a resection of a sigmoid colon, from a known, preexisting gastric ulcer. One bled in the early postoperative period from a pre-existing peptic ulcer, after having undergone a combined abdominoperineal resection of the rectum. The fifth and last case had a perforated duodenal ulcer and had a severe hemorrhage five days postoperatively.

TABLE 3.—*Average Hydrochloric Acid in Ulcer and Nonulcer Patients*

	Preoperative *	Postoperative †
6 Ulcer patients	8.80	30.32
8 Nonulcer patients	5.10	12.33

* Average for 12 hr. in mEq. per liter.
† Average for 48 hr. in mEq. per liter.

Among the patients with known ulcer who developed complications after trauma or surgery, the following case is by far the most interesting and best documented.

REPORT OF A CASE

J. D. C. was first admitted to the Louisville General Hospital in June, 1951, with a calculus of the ureter. He gave a history of peptic ulcer for about 10 years. For the previous year he had had few or no gastrointestinal symptoms. He was subjected to cystoscopy and manipulation of the ureteral calculi. The patient vomited on the second, third, and fourth days after this procedure. Although detailed records of his complaints are not written in the chart, he was put on a suspension of aluminum oxide, glycerine and sodium benzoate (Amphojel) at that time. On the fourth postoperative day, the patient signed out of the hospital and went to the Kentucky Baptist Hospital. There, a perinephric abscess was drained. Again the progress notes described only complaints relating to the urinary system, but again the patient was placed on Amphojel.

The patient was next seen 18 months after the original admission; he had fallen the day of admission and had suffered a comminuted fracture of the right elbow. At this admission the patient stated that he had vomited blood during the treatment for his perinephric abscess. (This is not in the records of the Baptist Hospital.) After an unsuccessful attempt at closed reduction, an open reduction was done three days after admission. The following day the patient vomited approximately 1 pt. (473 cc.) of blood and required transfusions. He was put on an ulcer diet and antispasmodics. He signed out on the eighth day after admission.

The patient was not seen, except in the orthopedic clinic as a follow-up patient, for the following two years. Then, on Nov. 10, 1953, he was admitted after having fallen about 20 ft. (7.6 meters) from a scaffold. He had sustained fractures of the right humerus, compression

fractures of the lumbar vertebrae, and multiple fractures of the transverse processes of the lower dorsal vertebrae. The patient stated he had not had any gastrointestinal symptoms for the previous six months.

On admission a nasogastric tube was put into the patient's stomach and connected to continuous suction. This was done because of abdominal distention. From about the sixth hour after injury and for a period of 12 hours, the material aspirated from the stomach was collected. Analysis showed little or no acid present. The continuous gastric suction was continued, and specimens were collected every four hours. The following day, the acid secretions ranged between 20 and 57 mEq. per liter, and about 1,400 cc. of gastric secretion was put out.

During this same day, the patient developed marked, generalized abdominal tenderness, and distention, and considerable blood was obtained through the nasogastric tube. (The presence of blood undoubtedly depressed the free acidity determinations in the gastric fluid.) At that time it was believed that the patient was bleeding from a duodenal ulcer. For the next few days he was treated by transfusions and continuous suction, and, although the patient produced an occasional reddish-tinged fluid through the gastric tube, he seemed to improve. By the seventh day after admission the patient was doing much better. The abdomen was flat; the bowel sounds were active, and there was no bleeding from the Levin tube. The Levin tube was clamped, and the patient was placed on surgical liquids. He had a bowel movement this day.

Several hours after the tube was clamped, the patient developed a severe acute abdominal pain with rather marked distention and the pulse rose to about 120. The blood pressure dropped markedly. At this time a diagnosis of perforated duodenal ulcer was made. Transfusions were started, and the patient was taken to the operating room. Exploration showed a perforated, bleeding, prepyloric ulcer. Subtotal gastrectomy was done. At the time of operation peritonitis was present, which was thought to be about 48 to 72 hours' duration. He died on the third postoperative day. This patient probably had a small leak at the time he was bleeding, which was controlled by the continuous gastric suction.

COMMENT

The exact incidence of activation of peptic ulcer by trauma or surgery is not known. However, such activation is not rare. No formal search has been made through the records of other hospitals in our community, but informally we have heard of several such cases.

With these findings in view, we recently reviewed the records of all patients in the Louisville General Hospital, from 1945 through 1949, for whom a diagnosis of duodenal ulcer was made. We found 42 patients who had a diagnosis of peptic ulcer and who had subsequent surgery. These selected patients did not have surgery related to the stomach. These 42 records showed only 3 patients who had definite activation of their ulcers following this surgery. We do not believe that the incidence in this series is high enough to warrant the assumption that surgery or trauma can or commonly does produce activation of ulcers. One of the characteristics of peptic ulcer is recurrence, and to show such a relationship, we must show that recurrences are of a more frequent order after surgery or trauma than in cases not having surgery or trauma.

Our observations of gastric secretion show that in the ulcer or nonulcer patient there may be a marked increase in the gastric acidity during the first 48 hours after such stress. This occurs most uniformly in the ulcer patient, and the acidity may frequently attain levels found in patients with active ulcers.

In view of the fact that patients frequently eat little or nothing for 48 hours after surgery or trauma and in view of the highly concentrated gastric secretions occurring during this period after trauma, we cannot avoid the suspicion that there may be a real causative relationship between such stress and the activation of ulcers.

Seymour Gray [2] has shown that the administration of corticotropin (ACTH) or cortisone will increase the acidity of gastric juice about 200%, and several reports have shown that these agents will activate preexisting peptic ulcers, not uncommonly leading to hemorrhage or perforation. There is ample evidence that there is a marked drop in the eosinophile count following operation, but to date it is not proved that this adrenocortical response is solely or even a part of the mechanism of the increase of the acid or the activation of the ulcer.

Incidentally, we have performed eosinophile counts on all of our patients, and they have shown a marked drop both at and also immediately after operation. These effects will be discussed in a separate paper.

Cushing [3] described new, acute ulcers after certain neurological lesions, and he attributed these effects to vagal stimulation. Acute ulceration of the intestinal tract has also been found after other lesions. Herbut [4] reported five acute ulcers after distant operations. However, these acute ulcers may be an entirely different disease process from that of the true chronic peptic ulcer.

In recent times, since the popularization of vagotomy by Dragstedt, it has been widely assumed that the psychosomatic and stress factor of peptic ulcer is mediated by the vagus nerves. Our findings make us wonder whether the adrenocortical hormone is not also, or even chiefly, responsible for this effect.

We feel that further observations must be made to determine the roles of vagal and adrenocortical mechanisms in the production of the hypersecretion of gastric juices.

SUMMARY AND CONCLUSIONS

Gastric secretions were aspirated for a 12-hour period before surgery and for the first 48 hours after surgery in six ulcer and eight nonulcer patients.

Analyses of these secretions for hydrochloric acid in the eight nonulcer patients showed a definite rise in three patients, and in two additional patients the concentrations were in the range found in patients with active ulcers. All of the six ulcer patients showed a rise, and three of these showed concentrations in the ulcer range.

A patient is reported who suffered three separate traumatic incidents. After the first he required antiacid therapy; after the second, he vomited blood and required transfusions, and after the last, he bled, had a perforation and died.

Trauma, surgical or accidental, causes a rise in gastric acidity during the first 48 hours thereafter. In patients with preexisting quiescent ulcers, this rise frequently attains levels found in patients with active ulcers.

The rise in acidity may be related to the activation of the quiescent ulcers in the cases we have reported.

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REFLECTIONS ON SURGICAL TREATMENT OF DUODENAL ULCER

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MEDICAL literature of today includes many fine reports of objective observations in varied experimental studies or detailed data concerning some facet of clinical investigation of the surgical patient. Such reports are essential as they offer the reader evidence of one type or another on which to base conclusions regarding the particular study in question. On the other hand, they may fail to express the broad views of the author regarding the particular problem under study. For example, many excellent contributions to the surgical literature on duodenal ulcer deal with detailed studies of gastric acidity, gastric motility, incidence of recurrent ulcers, results of a certain type of operation, and other related conditions, but they may not express the more general thinking of the author in the surgical management of patients who have duodenal ulcer. Consequently, it seemed that it might be appropriate to present a few general remarks without benefit of statistical data or experimental observations on the surgical care of the patient who has a chronic duodenal ulcer. These remarks might logically be presented from the viewpoint of certain preoperative, operative, and postoperative considerations.

PREOPERATIVE CONSIDERATIONS

One of the first questions which comes to the surgeon's mind when he sees a patient with duodenal ulcer is whether medical or surgical treatment should be advised. Often this is not a difficult decision as the evidence is such that indications are definite and clear-cut. Borderline situations are encountered, however, which require careful thought and the balancing of certain probabilities, such as likelihood of relief of symptoms by medical management, ability of the patient to follow a proper medical regime, operative risk now or later, probability of occurrence of serious or emergency complication if operation is not performed, and attitude of the patient toward medical or surgical treatment. The usual indications for operation, which may vary somewhat in the certainty with which they indicate the desirability of operation, include acute perforation and perhaps subacute perforation, obstruction which may be sclerotic or largely inflammatory in type, bleeding which may be acute or have occurred in the past on one or more occasions, failure of adequate response to medical management, or some question regarding whether a given lesion actually is a benign duodenal ulcer or a carcinoma at the outlet of the stomach. It is not the purpose of the present discussion to consider in detail the indications for and timing of the surgical treatment of duodenal ulcer, as this is a subject in itself, but rather to consider some indications for surgical management after it has been

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decided that operation should be performed. In passing, it might be said that my associates and I operate on only 10 to 15% of patients that we see with duodenal ulcer. Medical management is instituted in the remainder.

In the surgical treatment of duodenal ulcer as in the surgical management of other conditions for which there may be a varied choice as to the exact procedure to be performed, a given author often makes a study of the results of one type of operation and gives the impression that this is the only procedure which should be performed. Obviously, there are many variables evidenced by the patient who has a duodenal ulcer, including age, general health, weight, activity of the ulcer process, amount of gastric secretion produced in an average period of 24 hours, magnitude of the neurogenic element, the presence or absence of a strong family history of duodenal ulcer, site of the lesion in relation to other structures such as the common bile duct and pancreatic duct, and so forth. Likewise, there are variables in the surgical procedures that can be performed, ranging in degrees of control of gastric secretion and extent of surgical procedure from high gastric resection associated with vagotomy to gastroenterostomy alone. It therefore seems appropriate that the variables presented by the patient should be considered in each individual case in relation to the type of surgical procedure best suited for the individual patient. Some of these variables which the patient manifests are evident prior to the time of operation. Others become known only after the abdomen is opened and the lesion itself is carefully inspected.

Speaking first of those which are apparent upon examination of the patient, an excellent discussion of one aspect of this subject which deals with weight of the patient has been presented by Zollinger.[1] This author emphasized the importance of using the preoperative weight of the patient as compared with his calculated ideal weight as an important indication in selecting the type of operation best calculated to be followed by a satisfactory postoperative result with particular reference to the patient's nutritional status. He observed that whereas the majority of patients who were overweight prior to "an extensive Hofmeister gastric resection" held their ideal weight postoperatively, the reverse was true for the majority of patients who were below their ideal weight at the time of operation whether or not they had at one time been above this weight. A conservative operation such as gastroenterostomy and vagotomy significantly increased the chances of this latter group of patients to maintain a satisfactory postoperative weight.

It seems perhaps that in this country we have been guided in the selection of operation for the patient with duodenal ulcer too completely by the incidence of recurrent ulceration. Probably the postoperative functional result and nutritional status of the patient should receive more consideration. Apparently, this aspect of the problem has received more consideration in England and elsewhere, as operations designed to restore the "gastric pouch" are advocated as a standard procedure by some authors.* In addition to considering the preoperative weight of the patient, as advocated by Zollinger, it has appeared to me worth while to consider the patient's normal appetite and whether or not he is a "good eater" when healthy. If so, he may well continue in the same habits after partial gastrectomy. However, if he has never had a very large desire or capacity for food, these characteristics may well become accentuated after a major portion of the stomach is resected. In contrast,

* Reference 2, and Wilkie, D.: Personal communication to the author.

he may do definitely better in this regard after gastroenterostomy and vagotomy. If one grants that the incidence of jejunal ulcer may be somewhat higher after gastroenterostomy and vagotomy than after high gastric resection, should such an ulcer form, gastric resection can be performed at that time with expectation of no further recurrences. On the other hand, the majority of patients for whom this conservative operation has been selected should be enjoying a favorable functional result, which might not have been experienced had gastric resection been performed originally. Likewise, one may encounter the occasional patient of advanced years who has become gradually depleted from the obstructive effects of a sclerosing process in the duodenum, incident to a previously active duodenal ulcer. This patient may have lower values for gastric acid than are normal for his age and, in addition, have had no ulcer type of symptoms for many years. A conservative operation under these circumstances may well seem advisable in comparison with high gastric resection because of the lesser magnitude of the surgical procedures and the better postoperative nutritional prospects if the stomach is preserved.

Considered in another manner, one might say that it would be desirable to control the ulcer disease without extensive removal of the gastric pouch if this is possible. It does seem to be possible in some patients and the problem is to select the proper patients for the conservative procedure. After all, the stomach was provided to serve some useful purposes, and, if disease such as duodenal ulcer can be remedied without sacrifice of most of the stomach, it would appear desirable. Wangensteen and his associate (MacLean [3]) have endeavored to accomplish this same purpose to some degree, with the additional desirable feature of maintaining normal activity of the pylorus, when possible, by performance of tubular gastric resection. Encouraging early results with this operation have been reported.

Speaking further of the weight of the patient, there is a group of patients seen with duodenal ulcer represented by the barrel-chested, obese fellow who presents a well-rounded belly and a firm, thick abdominal wall. Commonly, for some reason that is not too clear, he may have a small stomach, situated high and deep in the abdomen and placed in a virtually transverse direction. Usually, the duodenum is deep within the abdomen, which makes it less accessible for adequate exposure. Gastric resection can be performed on such a patient but I think only with some increased operative risk because of the difficulty of the procedure and the definite possibility that less than the optimal amount of stomach might be resected, at least by most surgeons. Under such circumstances, it seems desirable, if the patient's condition will permit, that medical management of the ulcer combined with an effective weight-reduction program be instituted prior to operation. The patient need not necessarily lose weight to an ideal level, as a recent loss of 20 or 25 lb. (9.1 to 11.3 kg.) will make a great technical difference in the performance of the operation even though the patient is still obese.

Considering for a moment another group of patients, as seen preoperatively, there appears to be a place for high gastric resection, associated with bilateral vagotomy as a primary procedure. I refer to a group exemplified by a young man in his twenties, perhaps with a strong family history of duodenal ulcer, who has severe symptoms which are difficult to control at best for more than a few months at a time, extremely high values for gastric acids, and an obviously large neurogenic element in his disease. From past experience it has been learned that this type of person is a fine prospect for recurrent ulceration after any "ordinary" type of oper-

ation has been performed for duodenal ulcer. Under these circumstances, it seems reasonable to provide him with the maximal protection against recurrence at his initial operation. Vagotomy combined with high gastric resection offers this maximal protection. Since utilizing this selection of operation for patients of this type, I have been pleased with the excellent results that have been obtained in a group of patients who previously frequently presented recurring problems.

It is true that not every patient needs the same protection from the acid-pepsin factor of gastric juice to control or overcome his ulcer disease. This difference is quite evident between the group of patients whose ulcer disease can be controlled quite satisfactorily by medical measures and those patients who can obtain only partial, or at best temporary, relief by such treatment. Likewise, not all patients for whom surgical treatment becomes necessary require the same degree of reduction in gastric secretion to secure a satisfactory result. In some patients, an operation which effects maximal reduction of gastric secretion may be followed by a less satisfactory functional result than an operation which effects less extensive reduction of gastric secretion but which accomplishes an adequate reduction to control the ulcer disease. In short, it appears reasonable to choose the particular operation best suited for the individual patient rather than subject every patient to a uniform and standard surgical procedure. True, even when such practice is followed, a standard surgical procedure such as high gastric resection may be performed in the large majority of patients (perhaps 80 to 85%).

OPERATIVE CONSIDERATIONS

The foregoing remarks indicate that, if the surgeon is so minded, he may have chosen at the time of surgical consultation what he considers to be the desirable operation for a given patient who has duodenal ulcer. Currently, my preference in surgical treatment of the patient who has duodenal ulcer is for doing a partial gastrectomy (75%) and severing the duodenum distal to the ulcer and establishing a posterior Hofmeister-Polya type of anastomosis. This is the standard type of operation which is employed unless some factor or factors appear to indicate the desirability of some other procedure. It is possible that as time progresses, some other form of operation, such as resection of the distal half of the stomach combined with vagotomy, tubular gastric resection, or some other modification, may appear more desirable. At the present time, however, these procedures are in the phase of evaluation, and it would appear undesirable that they be employed generally until further experience has accumulated.

From time to time, one sees reports in the literature which enthusiastically support the Billroth I type of operation in the treatment of duodenal ulcer. It has been my observation that as the years pass, the enthusiasm which a given surgeon has for this operation frequently becomes less intense. This type of operation has certainly been followed by good results in a number of patients, but it does not completely eliminate dumping symptoms, postoperative nutritional problems, or recurrent ulceration. If a surgeon becomes too enthusiastic about the Billroth I operation, he may stretch the reasonable indications for its use, with certain undesirable results, namely, inadequate resection of the stomach, establishment of an anastomosis that is not free of tension, or utilization of a duodenum which is too

extensively diseased, either by ulceration or narrowing. Lack of appreciation of the excellent results which can be obtained by other types of operations may occur if the same type of operation is performed in virtually every case. It seems doubtful that the Billroth I type of operation is well chosen except in a limited number of patients who have duodenal ulcer.

The preoperative choice of operation may be altered after abdominal exploration with particular reference to the findings in the duodenum. It is granted that with increasing experience, which usually develops increasing skill, a surgeon may be able to perform high gastric resection and sever the duodenum distal to the ulcer in virtually every patient. This does not necessarily mean that it can be done in every case without some increased risk as regards healing of the duodenal stump or interference with the common bile duct. Nor does it mean that those of us with average experience or ability can accomplish such a procedure in all cases without additional hazard.

Those who favor the performance of gastric resection in all operations for duodenal ulcer might suggest that in circumstances of this type the stomach should be severed proximal to the pylorus, the prepyloric mucosa excised, and the gastric stump closed, as advocated by Bancroft.[4] Perhaps a procedure of this type can be accomplished with the usual risk of postoperative complications and with late results which compare favorably with those obtained by any other type of operation. There have been few reports of significant series of patients handled in this manner, however, and the postoperative complications have not always been fully discussed. Personally, I never feel too happy about the closure of the stump which is obtained with this form of operation, and I seldom employ this procedure. Again, it would seem reasonable to think of gastroenterostomy and vagotomy as an alternate procedure to gastric resection when unusual technical difficulties are anticipated in satisfactory management of the duodenal stump.

Details of management of the duodenal stump when gastric resection is performed will not be discussed at this time. I might say, however, that I do not know of any convincing evidence which indicates a higher rate of recurrent ulceration when the ulcer is left in place and the duodenum is severed distal to the pylorus and closed proximal to the ulcer than when the ulcer is excised. True, when the duodenal stump is closed in this manner, some technical difficulties may be encountered unless adequate attention and care are given to important details of the closure. Actually, I believe that leakage of a duodenal stump, which should be a truly rare complication, is more often caused by increased intraluminal pressure in the duodenum than by primary failure of the suture line in the duodenum to heal satisfactorily. This of course, assumes that closure of the duodenal stump was accomplished in an acceptable manner, without tension and with an adequate blood supply of the sutured tissues. Increased intraduodenal pressure after gastric resection commonly is the result of back pressure, from one cause or another, in the proximal limb of the jejunum.

It is granted that if gastric resection is performed for duodenal ulcer the most important consideration in the prevention of recurrent ulceration is removal of an "adequate" amount of stomach. However, what is adequate for one person may not be adequate for another. It is generally stated that two-thirds to three-quarters of the stomach should be removed, with the preponderant opinion favoring the larger of the two amounts. It is difficult for the surgeon to estimate accurately the

percentage of the stomach resected, although weight, surface area, and other measurements may be used for this purpose. For some years, my associates and I have used a formula developed by Heinrich [5] which is dependent on weight of the resected portion of the stomach divided by thickness of the muscularis at the upper edge of resected portion of stomach. This method appears to afford rather accurate estimates in the majority of cases.

Granted the importance of the extent of gastric resection in the prevention of recurrent ulceration, this is not the only significant consideration in the execution of this operation. In other words, the type of anastomosis that is established may influence the incidence of postoperative complications and dumping symptoms, as well as the motor function and nutritional status of the patient. As mentioned previously, the posterior Hofmeister-Polya anastomosis is preferred. In the execution of this operation, resection is carried higher along the lesser curvature of the stomach than on the greater curvature. A gastrojejunal stoma is established which is equal to the diameter of the jejunum. This extends from the greater curvature of the stomach toward the lesser curvature. It is thought that a larger stoma may result in a higher incidence of dumping symptoms. The proximal limb of the jejunum is anastomosed to the stomach at the lesser curvature. The length of this limb is such that only one finger can be inserted behind the jejunum between the ligament of Treitz and the line of anastomosis. The end of the gastric stump is brought below the transverse mesocolon through an opening in this structure which is placed to the left of the middle colic vessels and near the base of the mesocolon, where the gastric remnant would normally lie. The mesocolon is sutured to the stomach at least 4 or 5 cm. proximal to the line of anastomosis. This decreases the possibility of a jejunal limb being pulled above the opening in the mesocolon. Care is taken to invert only a minimum of tissue as the anastomosis is established. It is thought that an anastomosis of this type is preferable to other types because of the low postoperative incidence of such complications as leakage of the duodenal stump, gastric retention, dumping symptoms, and late obstruction. The type of operations which are not preferred include the full Polya and the anterior anastomosis or attachment of the jejunum to the stomach so that the distal jejunal limb leaves the lesser curvature of the stomach.

POSTOPERATIVE CONSIDERATIONS

Opinions differ regarding the early and late postoperative care of patients who have had an operation for duodenal ulcer. One of the first considerations which arises is whether an indwelling tube should be left in the stomach upon completion of the operation. Let us consider first the patient who has undergone partial gastrectomy of the type described. It has been my experience that it is the rare patient who has any significant gastric retention after such an operation, although many surgeons do leave an indwelling tube in the stomach postoperatively as a routine procedure. If gastric retention occurs, the tube serves a very useful purpose and the advantages of having the tube in place outweigh the disadvantages. In the absence of gastric retention, however, the opposite appears to be true, and in my opinion more harm than good may result from the presence of the tube. Perhaps the disadvantages of an indwelling gastric tube in the absence of gastric retention have not been given sufficient thought. Among these might be included discomfort to the patient, interference with coughing and usual normal mobility on the part of the patient, irritation of the nasopharyngeal-esophageal tissues which may become

pronounced, and aspiration of fluid and secretions from the stomach which only have to be replaced usually by intravenous administrations. Granted, if there is definite indication or need for continuous gastric aspiration, it should most certainly be employed, but in the absence of such need, its use seems undesirable. It, therefore, appears preferable not to penalize every patient by the routine use of postoperative gastric suction but to use this type of treatment only for the patient who actually needs it. In my experience, this need is quite uncommon and may be indicated by a sensation of epigastric fullness, hiccup, nausea, or vomiting. If any of these symptoms develop, a tube may be passed into the stomach and permitted to remain or not, depending on the amount of gas or fluid aspirated from the stomach and the relief which is afforded the patient.

The situation appears to be different when a vagotomy has been performed whether this is done in association with gastroenterostomy, a gastric resection, or by itself, perhaps for jejunal ulcer after a previously performed gastric resection. Although many patients who have undergone vagotomy will not have any significant postoperative gastric retention, it is difficult to predict in advance which patient will and which one will not have some retention. I am not sure but that even in these patients intermittent aspiration to determine who needs continuous suction could be employed with satisfactory results. It is my practice, however, to insert an indwelling gastric tube in all patients who have undergone vagotomy. Mild suction is applied constantly for the first 24 hours. After this period, only intermittent suction is used, perhaps one hour out of each three or four hours. As soon as it is demonstrated in this manner that the stomach is emptying satisfactorily, the tube is withdrawn. This is usually done 48 to 72 hours after operation.

The postoperative feeding program of the patient who has undergone a partial gastrectomy for duodenal ulcer is a matter of great importance. Consideration of this program may be divided into the early and late postoperative periods. I am certain that in past years we starved patients unnecessarily during the first week or so after operation. An attempt was made to make up for this with various solutions administered intravenously—always a poor substitute if the patient can take fluids and nourishment by mouth. The result was that the patient regained strength and normal vigor at a delayed rate. Oral administration of fluids is now usually started during the second 24 hours after operation. Subsequently, a graduated diet of increasing caloric content is given so that by the end of the first week after operation the patient is taking by mouth an adequate normal caloric intake. This is arranged in the form of three main meals a day, with only small feedings between meals.

In the past, relatively small regular meals and relatively large intermeal feedings have been employed, and some surgeons still prefer such a program. This in effect amounts to six feedings of almost equal size during each day. It was my experience with such a program that the patient rapidly became accustomed to such a plan of feeding so that later he experienced difficulty taking meals of regular size. Obviously, in order for the patient to maintain or gain weight he must have an adequate caloric intake. Furthermore, the pleasant and natural way for him to do this is to eat three main meals a day like anyone else. To get back to this normal way of doing things is quite important, I believe, and is greatly aided by proper indoctrination during the second week after operation. If this is carried out in a satisfactory manner, the incidence of postoperative nutritional problems after partial gastrectomy is low.

I believe the important points to be emphasized to the patient during the second week after operation are, as he probably already knows, that his stomach is smaller than it used to be (assuming gastric resection has been performed) and that it is natural for him to experience some fullness after eating a fair-sized meal. He should be encouraged to "work towards" eating three regular meals of normal size each day, however, and should be told that as he continues to do this, the sense of fullness which he experiences during the early postoperative period will gradually disappear. If he "gives in" to this sense of fullness and eats so little at one time that this sensation is not experienced, he will gradually eat less and less at one time, lose weight and strength, and be generally unhappy. Obviously, such a situation must be avoided, and efforts must be made to be certain that this does not happen.

Occasionally, despite a full discussion with the patients and encouragement to increase the gastric capacity, some patients will say they "just can't do it." If this situation develops, the time to start correcting it is as soon as it becomes apparent. The patient should not be dismissed until he is eating in a satisfactory manner. If he is dismissed previously, a serious nutritional problem may develop and become increasingly difficult to correct with the passage of time. On the other hand, if the patient is followed closely, seen daily, and encouraged during this period of early postoperative difficulty, it is rare indeed that the situation cannot be corrected. During this time, the patient is served a diet of known caloric content and, if necessary, an accurate account of the caloric intake is charted each day. Such a program may require only one extra week of careful care, or, in the case of a patient with a large neurogenic factor and other unfavorable extraneous influences, it may require as long as four or six weeks. The point is, however, that the patient should receive careful attention as long as necessary to get him started on the "right track." When this is once accomplished, he will normally continue to do well and have a happy result from his operation. If it is not done, an undernourished and unhappy patient may well be the result. In brief, it is the responsibility of the surgeon not only to cure the patient of his ulcer disease but also to see that he has a satisfactory functional result after the operation.

Deprivation of most of the gastric pouch may present difficult problems in some patients but, if the program as outlined previously is followed, it has not been my experience that operations to make a substitute gastric pouch of one type or another have been necessary. As mentioned earlier in these remarks, it seems wise to make a choice of operation preoperatively for the individual patient, based in part upon the anticipated functional result from a nutritive point of view. Some patients just do not tolerate removal of a major portion of the stomach as well as others do, even though the ulcer disease is cured. In some cases, this may well be the determining factor in the selection of a conservative procedure such as vagotomy and gastroenterostomy.

The question arises concerning how long and how carefully the patient should follow an ulcer-type of diet postoperatively. When a patient has an operation for a condition such as duodenal ulcer, he likes to think that he will be cured after the operation. Naturally, the surgeon feels the same way, and, of course, the patient is cured in a high percentage of cases. A prolonged postoperative medical program after operation, therefore, seems undesirable and unnecessary. It is my practice to advise the patient to follow an ulcer-type of diet for one month after operation. He is told that after that period of time he may eat a general type of diet, having some

foods of any type which he wishes. He is advised, however, to have some regard for his stomach, to eat at fairly regular intervals, and not to make a practice of eating only rough, coarse or highly seasoned foods.

Many other comments could of course be made on the surgical treatment of duodenal ulcer, based on technical considerations, experimental observations, clinical data, and practical experience. The foregoing remarks are a few, however, which appear to be of significance.

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DEVELOPMENT OF OBSTRUCTIVE RESECTION AND RANKIN CLAMP FOR LESIONS OF COLON

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THE PURPOSE of this paper is twofold: first, to trace the development of obstructive resection for lesions of the colon, and, second, to discuss the use of the Rankin Clamp, which, although originally designed as an instrument for closed anastomosis of the colon, early became identified as an essential aid in undertaking obstructive resection.

Sixty-one years ago, discouraged because of the prohibitive mortality rate that attended resections of the colon (well over 50% in the 58 cases recorded to that date), Block, of Copenhagen, devised an exteriorization procedure which permitted delayed opening of the bowel. However, it was not until 1902 that the maneuver became popular, owing then to the influential advocacy of Mikulicz, by whose name the operation generally became known throughout the country. Although the immediate mortality rate soon was reduced more than half and the popularity of the so-called Mikulicz operation continued for nearly 25 years, a few discerning surgeons early recognized the limited nature of this type of resection, which was followed by a high recurrence mortality. Among these were Hochenegg, McGraw, Allingham, and Paul, but there is little evidence that would lead one to believe they influenced many surgeons to undertake the more radical procedures they advocated. It is wholly possible that this lack of enthusiasm was due to a greater mortality which accompanied the more formidable operations in the face of obstruction which accompanied most of these lesions of the colon. Decompression measures, such as cecostomy or proximal colostomy, preliminary to or at the time of resection, seldom were undertaken prior to 1920.

In the decade 1920-1930, the pace of improvement in surgery of the colon rapidly increased. This progress was spearheaded by Dr. Fred W. Rankin, who, at the beginning of this period was on the surgical staff of the Mayo Clinic, later professor of surgery at the University of Louisville and then surgeon to the Lexington Clinic and, during its latter half, head of a section in surgery at The Mayo Clinic. He was concerned not only because hospital mortality remained higher for resection of the colon than in any other section of the gastrointestinal tract but also for the reason that the Mikulicz procedure, the one most frequently employed, was in most instances only a palliative measure. The popular opinion that the Mikulicz operation was attended by a small mortality stemmed from the fact that only two large series of cases had been reported, and in these the hospital death rate was under 15%. Follow-up statistics were inadequate and in most instances were reported only for three-year survivals.

From the Stuart Circle Hospital.

Dr. Rankin found in a study of 183 Mikulicz procedures performed at The Mayo Clinic that, although the hospital mortality was unusually low for that period, 9.6%, there was, however, a 7% recurrence in the abdominal wall, despite elaborate precautions taken in the later years of this study to prevent such implantations of cancer cells into the wound. At about the same time, in 1923, Miller reported a review of all cases of cancer of the colon who had been admitted to the John Hopkins Hospital from 1889 to 1919. It presented a most discouraging experience. The total number operated upon was 129, and in 70, or 56%, resection was done, with 24 deaths, a mortality of 35%. A short time later, statistics from The Mayo Clinic, which for the most part reflected their experience prior to 1920, revealed an over-all mortality of 19.7% in 433 cases in which resection of the colon was undertaken, and in the 333 in which resection was done with the intention of cure, the rate was 16.21%. Similarly, the average mortality at Peter Bent Brigham Hospital in a series of 154 cases, as reported by Chever, was 30%, whereas in a group of 85 radical resections with anastomosis the rate was 17.6%. There were many other, smaller series in which the mortality rate was even higher.

It occurred to Dr. Rankin about 1920 that the best solution to the problem of colonic resection was to accept the admirable principle of multiple-stage operations and at the same time to avoid the many disadvantages of the Mikulicz operation. He favored the procedure first employed as an expedient by Schede, in 1879, when he was unable to join together the two ends of resected sigmoid, and subsequently advocated by Hockenegg as the procedure of election. He had observed the occasional use of this procedure at The Mayo Clinic, where it had been used infrequently in the poorest risk cases, without proximal decompression and where, as a consequence, the mortality rate had been higher. Finally, in 1923, Dr. Rankin had his first opportunity to use the procedure to which the next year he applied the term "obstructive resection." In his monograph, "Surgery of the Colon," published in 1925, he wrote:

> The Mikulicz-Bruns type of operation finds its greatest field of usefulness as a palliative measure in growths that may be easily mobilized. Providing no attempt at gland dissection and bringing a cancerous growth in direct apposition to the cut surface of the abdomen its percentage of recurrence is higher than that of other types of resection. The ease of execution has popularized its employment and general statements as to its mortality and end-results are not confirmed by even a casual study of a group of cases. Twice in dealing with cancer of the middle segment of the colon, where there was little obstruction present, I have used a technic which might be called an obstructive resection and which I believe is an operation of election in certain cases because it may be accomplished quickly and easily. The first time I used it was upon discovery of a cancer of the transverse colon adherent to a huge fibroid. The colonic growth had not been suspected and was discovered at laporatomy. In the second case, it was used deliberately. The technic is a combination of the first two stages of an exteriorization procedure such as the Mikulicz operation. Providing for gas distention and intoxication, I have done an enterostomy in the small bowel and allowed the tube to drain.
>
> Heretofore, this procedure has been applied merely in the most extreme cases and with a consequent high mortality which does not indicate its true value. It may be performed very quickly and without shock or prolongation of operative maneuvers, and since the colon is mobile and accessible (in the left half) the thoroughness may be just as complete under this type of technic as any other.

It will be noted in Figure 1 that in the beginning two heavy clamps were applied to the two ends of colon, whereas a few years later the Rankin three-bladed clamp

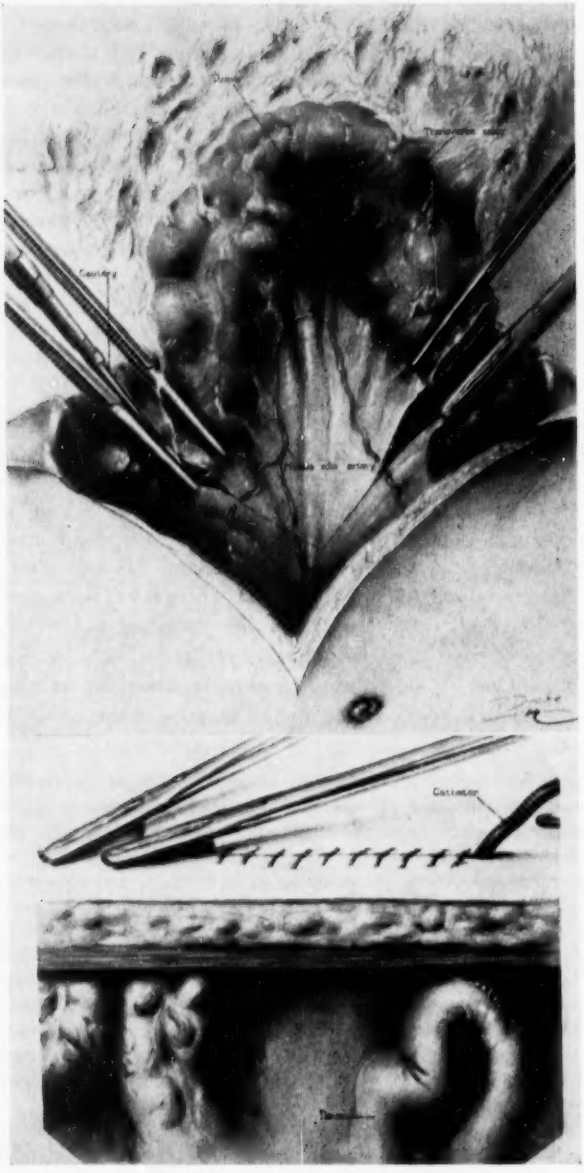


Fig. 1.—Obstructive resection as originally performed and reported (Rankin) in 1924. A special clamp is now employed (Fig. 2). Above, resection transverse colon; below, clamps in situ and enterostomy established.

was employed instead. This clamp, which he originated in about 1925 and which it was my privilege to help perfect in the experimental laboratories of Dr. Frank Mann, was designed to facilitate the closed anastomosis of the colon. It occurred to Dr. Rankin as he employed it for this purpose that, after the clamp had been applied to the two limbs of bowel and the segment harboring the lesion removed, one could either consummate the anastomosis or, if an unforeseen contraindication to anastomosis were encountered, the two ends clasped by the clamp could be brought out onto the abdomen as an exteriorization measure: in short, establish an obstructive resection. For flaccid, well-decompressed bowel, the narrow-bladed model (Fig. 2*A*) is adequate, but when the bowel wall is thickened from hypertrophy this clamp is not

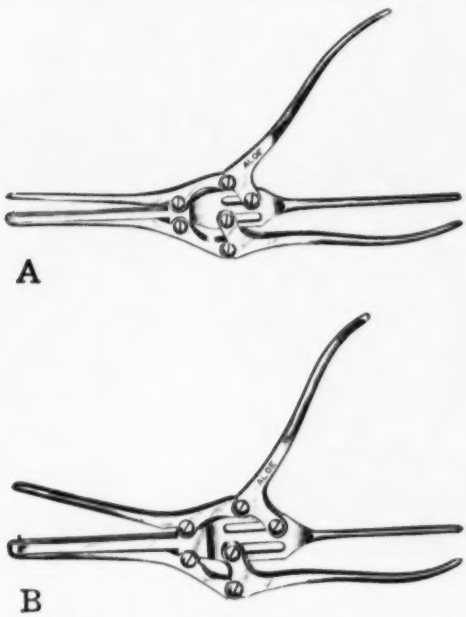


Fig. 2.—The Rankin clamp for closed intestinal anastomosis and obstructive resection: *A*, narrow blade for intestinal anastomosis; *B*, wide blade for obstructive resection.

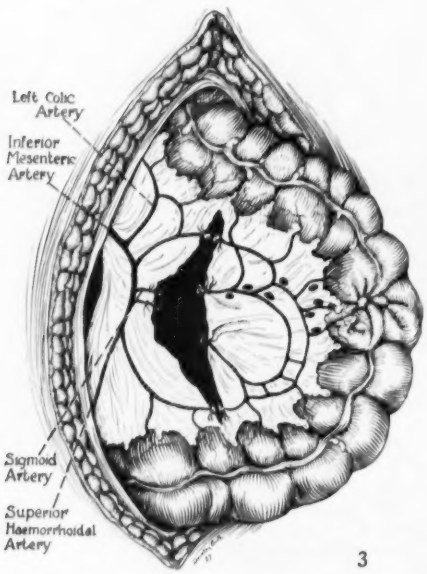
satisfactory. A sturdier model (Fig. 2*B*), the thicker blades of which could be opened wider, was therefore developed.

In 1928, after this clamp had been developed and some 50 operations had been performed, Dr. Rankin wrote:

> This multiple-stage procedure which employs the special three bladed clamp, permits primary resection of the colon and its contiguous lymphnode-bearing tissue with subsequent restoration of the lumen of the bowel. It is applicable to any portion of the colon that is mobile or mobilizable. The procedure is contraindicated in the presence of obstruction which should be first relieved by medical measures of decompression, cecostomy or colostomy. The operation is performed in two or three stages: (1) resection of segment of bowel harboring the growth . . . ; (2) destruction of the colostomy spur by application of clamps . . . ; and (3) surgical closure of the colostomy stoma where this is not of spontaneous occurrence.

Within a relatively short period of time, Dr. Rankin had ample reason to be enthusiastic over the relatively low mortality that accompanied his operation. The advocacy of primary resection and anastomosis by a few surgeons, based on small series of cases, continued. His comments on this were as follows:

Primary suture in the left half of the colon is rarely considered to be desirable. The blood supply to the colon is far from being as scant as has frequently been suggested, yet it is not so rich as in the small bowel or stomach, and infection and leakage at the suture line are too apt to occur secondarily to warrant frequent use of primary suture anastomosis. Advocacy of its employment has been founded on small series such as the 35 cases which were reported from the Peter Bent Brigham Hospital a few years ago by Cheever in which there were five deaths or a mortality of 14.2 per cent. The fallacy of attaching significance to statistical consideration of a limited number of cases has been demonstrated frequently. A striking illus-



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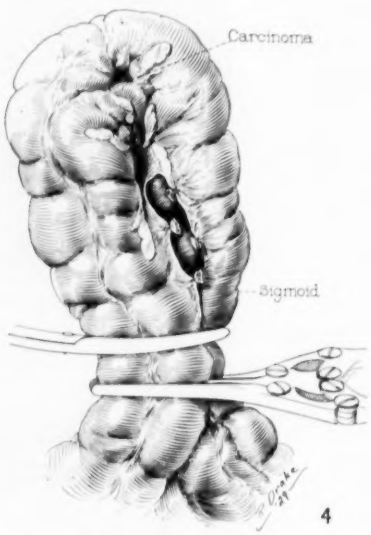

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Fig. 3.—Obstructive resection of the colon. The mesenteric blood vessels are ligated near their points of origin and a wide expanse of mesentery is sacrificed.

Fig. 4.—Obstructive resection. Mobilization completed. The special clamp has been applied to both limbs of bowel and the exteriorized segment of colon is ready for removal with cautery.

tration is an analysis of our first 100 consecutive obstructive resections. In the first 36 cases there was not a death, in the next 14 there were five deaths, and the mortality for the entire number was less than 10 per cent. The absence of mortality in the first 35 cases was not a fair criterion as to what could be expected from this procedure because these cases were carefully selected. Had the following 14 cases received attention first, the operation might have been discarded because of the prohibitive mortality (36 per cent).

Usually the mortality for primary suture of the colon has been greater than that reported by Cheever and the principal reason for its employment has been that shorter hospitalization is required than for the multiple-stage maneuvers. The desire to save time and expense to the patient should not warp one's judgment, for by spending more time preoperatively and in carrying out multiple operations, lower mortality and a higher percentage of satisfactory end-results may be the reward.

It should be borne in mind that during this period, peritoneal contamination and pulmonary complications accounted for approximately 90% of the deaths following operations on the colon, conditions which rarely are fatal today, owing to the availability of antibiotics and chemotherapy.

A few surgeons who had had little or no experience with obstructive resection criticized it as being less radical than primary resection and anastomosis. This was refuted not only by Dr. Rankin but also by T. E. Jones, Lahey and Cattell, David, Garlock, and by a number of others. In 1934, David published an article entitled

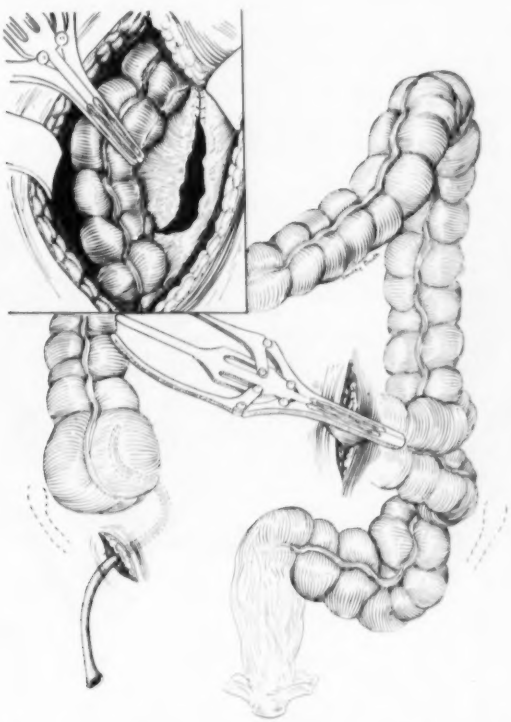

Fig. 5.—Completion of obstructive resection. The cecostomy is shown, the tube in the cecum being brought out through a stab wound in the right groin. The completed operation with the wound closed around the clamp holding the two ends of bowel is shown. The insert shows peritonealization of the raw surfaces left from mobilization.

"The Treatment of Carcinoma at the Rectosigmoid Junction by Obstructive Resection," in which he described his application of the Rankin procedure principle to selected lesions of the upper rectosigmoid. Lahey, who applied obstructive resection to lesions of both the proximal and the distal colon, said in 1945 (when he was still employing obstructive resection in all but 10% of lesions of the left colon):

> It is important to state, because of the confusion which exists in many minds about the old and original type of Mikulicz operation and the modern modification, that the procedure [obstructive resection] in no way differs in the extent of radicalness either in amount of

colon removed or in the area of adjacent mesentery and mesenteric glands included in the removal of the colon. It differs from primary removal and primary anastomosis only in the method of restoring the fecal stream and not in the radicalness of extent.

It was also the opinion of T. E. Jones, after 10 years' experience with obstructive resection, that it was fully as radical as primary removal and anastomosis. Previous to 1938, he favored resection of the colon in a one-stage procedure with immediate anastomosis. The mortality in this group of 128 cases was 14%. He felt this could be improved upon; consequently in January, 1938, he started a series of

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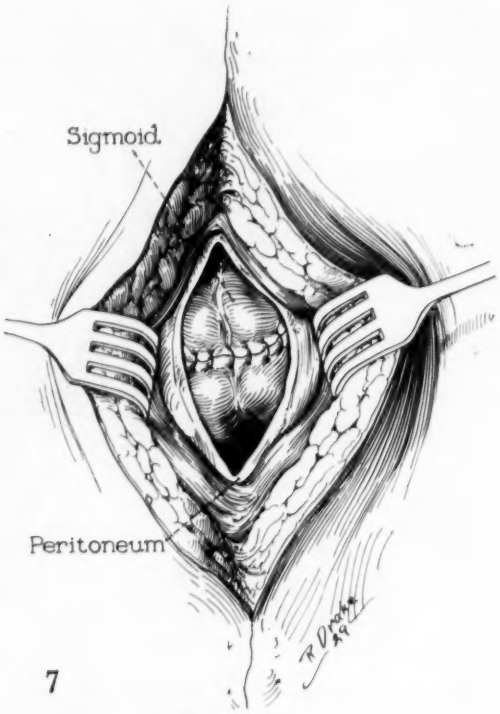

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Fig. 6.—After the Rankin clamp has been removed and wound is healed, the spur is destroyed by the application of clamps which necrose through it slowly.

Fig. 7.—Final stage of operation, showing closure of the colostomy. In more than half of the cases, this step is unnecessary as spontaneous healing takes place.

the Rankin procedure. His mortality in the first 77 cases was 6.5%, and later in a series of 117 cases it was reduced to 5%. Even as late as 1948 he employed obstructive resection to the exclusion of all other methods. For his entire series of cases the total hospital stay averaged only 28 days, including the period of preoperative preparation and the period following closure of colostomy.

With the advent of chemotherapy, and later the antibiotics, and more particularly after World War II, when improved sulfonamide drugs for oral use became available and the antibiotics became more plentiful, there developed a decided trend

away from extraperitoneal, multistage operations, such as obstructive resection. In 1947, preliminary to revision of our monograph on cancer of the large intestine, Dr. Rankin and I determined by questionnaire that 62% of 50 surgeons most interested in this field used primary resection and anastomosis in between 75 and 100% of cases. Now, five years later, primary resection and anastomosis have almost completely replaced obstructive resection, and rightly so. For 25 years, this procedure of Dr. Rankin's served a valuable purpose. It was the operation of choice of surgeons with the greatest experience in the field of large bowel surgery. It carried the lowest mortality of any radical measure for the removal of lesions of the colon and regional lymph nodes, and there have been as many five-year survivals following this procedure as there have been after primary resection and primary anastomosis. But now with a better understanding and utilization of preoperative preparation, especially as regards anemia and serum-protein deficiency, and with the almost complete elimination of peritonitis as a cause of death, there is little further need for obstructive resection, in which opinion Dr. Rankin also concurred.

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STRUCTURAL CHANGES IN HUMAN AORTIC HOMOGRAFTS

Study of Ten Cases

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INCREASING use of arterial homografts in the surgical treatment of various forms of arterial disease has emphasized the need for additional information concerning the biologic properties of transplanted vessels. The functional integrity of arterial homografts as well as the structural changes they undergo after transplantation in experimental animals has long been well known.* More recent experimental studies have amplified these observations, particularly as regards the influence of various methods of graft preservation.† Similar studies in man, however, have not been available. It seems desirable, therefore, to report our studies on the structural changes occurring in human aortic homografts from one day to one year following transplantation.

These observations are based upon 10 cases in which aortic bifurcation homografts were used to replace excised segments of the abdominal aorta, for arteriosclerotic aneurysms in 8 instances and for thrombo-obliterative disease in 2. The technique used in the performance of this operative procedure has been described elsewhere.‡ All the patients were men, and their ages ranged from 38 to 70 years (Table). The grafts were obtained at necropsy in nine patients and at operation in one. In the last instance, the indication for the procedure was occlusion of the right iliac artery just distal to the anastomosis. It was found necessary to excise the distal part of the homograft, and a second homograft was implanted that is still functioning.

All the homografts used in these patients were obtained from relatively young adults dying mostly of injuries (Table). Two of the grafts were preserved by refrigeration in balanced salt solution and eight by freeze-drying. The technical details of preparation and preservation of the grafts by the latter method have been described elsewhere.[2] The period of preservation of the grafts prior to their use varied from 7 to 76 days (Table).

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From the Department of Surgery and the Department of Pathology, Baylor University College of Medicine, and the Veterans Administration, Jefferson Davis, and Methodist Hospitals.

* References 1 and 15.

† References 5, 7, 8, 9, 10, 12, 13, and 14.

‡ References 4 and 6.

METHOD

All specimens obtained at necropsy were removed within 12 hours after death. The aorta was transected just below the diaphragm and removed in continuity with the graft to a point below the bifurcation of the common iliac arteries. The specimen was placed in formalin (10%), and after fixation it was opened for inspection of the intimal surface and of the lines of anastomosis. Representative portions were taken for microscopic study from the proximal and distal structure lines and from the graft at the levels of the inferior mesenteric artery and of the bifurcation. Paraffin sections were made from each block, and one or more preparations were stained with hematoxylin and eosin, Masson's trichrome, and Weigert's elastic tissue stains.

RESULTS

Homografts 1 to 22 Days Old.—All five grafts in this group had been preserved by freeze-drying (Table, Cases 1 to 5). Grossly, they had the texture and appearance of the normal aorta. Extravasated blood was noted about the grafts, particu-

Table Showing Pertinent Data on Donors and Recipients of Aortic Homografts

Recipient		Donor		Age of Graft (Days)		
Patient	Age (Years)	Age (Years)	Cause of Death	Procurement to Transplantation	Transplantation to Necropsy	Cause of Death (Recipient)
1	53	34	GSW head	12	2	Coronary occlusion
2	61	30	Head injury	7	1	Coronary occlusion
3	68	34	Stab wound chest	8	22	Coronary occlusion
4	67	42	Stab wound abdomen	43	7	Renal failure
5	70	15	GSW chest	50	2	Cardiac failure
6	58	31	GSW chest	30*	44	Coronary occlusion
7	38	27	Sickle cell anemia	23	40	Cardiac failure
8	53	42	GSW abdomen	76	42	Rupture of left common iliac artery
9	62	25	GSW chest	28	70	Cardiac failure
10	62	32	Ruptured cerebral aneurysm	11*	399	Patient alive and well†

* Preserved by refrigeration in balanced salt solution; the rest was by freeze-drying.
† Specimen obtained at operation for occlusive disease of iliac artery.

larly at the sites of anastomosis. The adjacent host tissues were adherent more firmly to the graft 22 days old than to the transplants removed earlier. Atheromatous changes were extensive in the host aortas and iliac arteries (Fig. 1). The inner surface was smooth and uninvolved in one graft; mural thrombi not significantly encroaching upon the lumen were noted in two, and a thrombus filled the lumen of the graft portion of the right common iliac in two instances. The anastomoses were intact in all the transplants, although suturing had been accomplished through areas of atheromatous change.

The junction of host and graft vessels in each instance was distinguished microscopically by atherosclerotic changes in the former and lack of nuclear staining in the latter (Fig. 2). At each anastomosis there was a cleft filled with a wedge-shaped plug of fibrin that communicated with a similar deposit on the external surface of the graft and extended over the luminal surface of the host vessels and graft for varying distances. Beginning organization of this fibrin layer at the anastomoses and also of the wedge-shaped fibrin plug was noted in the graft 22 days old. In addition, there were infiltrations with granulocytes, lymphocytes, plasma cells, large mono-

nuclear cells, and, about the suture material, giant cells of the foreign body type. Near the anastomoses in the grafts one to seven days old, the intima was represented by a layer of fibrin of varying width, and the media was amorphous and acellular with normal-appearing elastic fibers (Fig. 3). In the adventitia of the grafts 7

Fig. 1.—Homograft 7 days after transplantation. Atherosclerotic changes in the host vessel contrast with the smooth intimal surface of the graft.

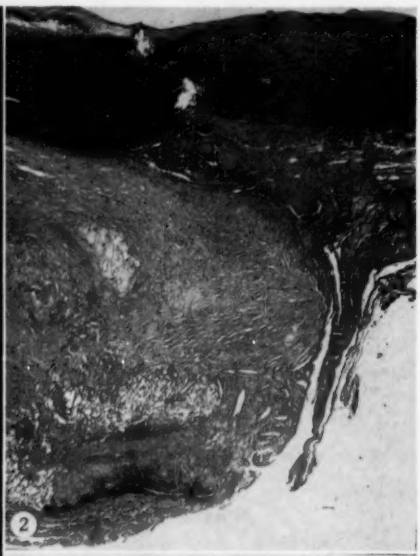


Fig. 2.—Proximal suture line of the 7-day-old graft shown in figure 1. There is marked atherosclerotic change in the host aorta and absence of nuclear staining in the graft. Weigert preparation × 12.

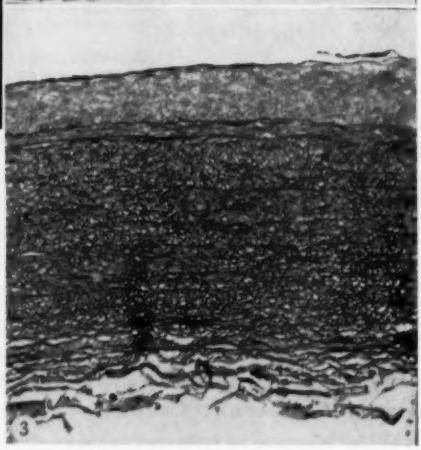


Fig. 3.—Microscopic appearance of the 7-day-old graft shown in Fig. 1, 3 cm. from the proximal anastomosis. Intima consists of a layer of fibrin. Double line of elastic fibers delimits the intima from the media. Elastic fibers of the media are clearly outlined. Weigert preparation × 12.

and 22 days old, there was new formation of connective tissue and there were infiltrations of erythrocytes, granulocytes, plasma cells, lymphocytes, and large mononuclear cells, some with brown granules in their cytoplasm. Near the midportion of the graft, an intimal layer was lacking, the inner surface being formed by elastic fibers of the media. In the grafts 22 days old, collections of erythrocytes were seen between the elastic fibers of the media.

Homografts 40 to 44 Days Old.—The three grafts, examined 40, 42, and 44 days respectively after transplantation, had been preserved by freeze-drying in two instances and by refrigeration in balanced salt solution in one (Cases 6, 7 and 8 in Table). Grossly the grafts had the texture and color of the normal aorta (Fig. 4). In fact, in one patient who was operated upon for intestinal obstruction one week prior to death, the graft was almost indistinguishable from the host aorta. In the

Fig. 4.—Homograft 40 days after transplantation. Graft has the appearance of a normal aorta and blends with the host vessels at the lines of anastomoses.

patient who died 42 days after operation from rupture of the left common iliac artery just distal to the anastomosis, blood was extravasated throughout the retroperitoneal space. In the patient who died from coronary occlusion 44 days after operation, there was a minute perforation in the right common iliac portion of the graft, and a hematoma surrounded the right common iliac artery extending to the inguinal ligament. There were extensive atherosclerotic changes in the host vessels adjacent

to the grafts. The periaortic fibrous connective tissue was firmly adherent to the grafts and was stripped with difficulty, particularly at the sites of anastomosis. The suture lines were intact. The intimal surfaces of the grafts were lined with thrombotic material that did not significantly reduce the lumens. The host aorta of the 42-day-old graft was dilated to over three times its usual diameter and was almost occluded by old and recent thrombi. The host common iliac arteries adjacent to the 42- and 44-day-old grafts were thin-walled because of endarterectomy at the time of grafting.

Microscopically, at the proximal anastomosis a plug of granulation tissue filled the cleft at the point of coaptation of graft and host aorta (Fig. 5). This wedge of granulation tissue extended outward toward the adventitia and separated the atheromatous intima and media of the host aorta from the acellular media of the graft. Giant cells of the foreign body type surrounded the suture material in the

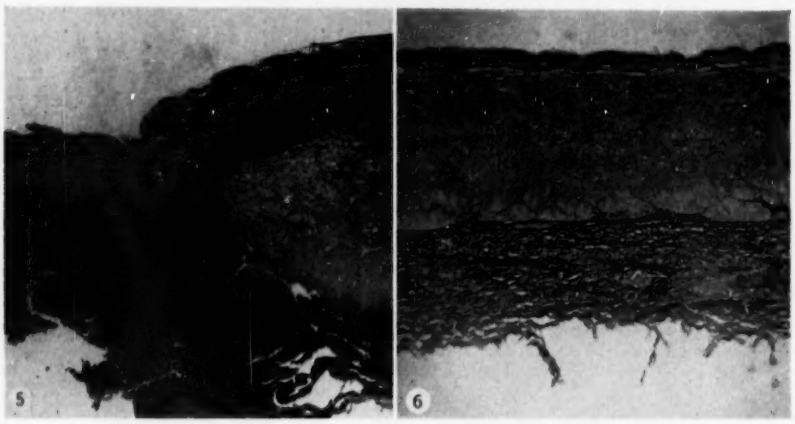


Fig. 5.—Proximal suture line of the 40-day-old graft shown in Fig. 4. A plug of granulation tissue fills the cleft at the anastomosis and extends outward separating the atheromatous intima and media of the host aorta from the acellular media of the graft. Trichrome preparation × 12.

Fig. 6.—Microscopic appearance of the midportion of the 40-day-old graft shown in Figs. 4 and 5. Wavy elastic lamina forms the intima. Pattern of the media is preserved. The newly-formed adventitia is almost the width of the media.

adventitia, while toward the intima these cells were scant or absent. The intima of the graft at the anastomosis was continuous with the granulation tissue filling the cleft and extending onto the graft for varying distances. Scattered cell nuclei were noted in the intima for about 1.5 cm. distal to the aortic anastomosis. The media was amorphous, and cell nuclei were absent. In the Weigert preparation, however, the elastic fibers appeared well preserved. The adventitia was composed of coarse collagenous bundles with occasional cell nuclei and young adipose tissue cells.

In preparations from the levels of the inferior mesenteric artery and the bifurcation of the aorta, the intima was represented in places by a layer of fibrin separated from the media by an inner elastic lamina. Elsewhere the inner surface of the graft was made up of elastic fibers of the media (Fig. 6). The media was less than half the width of the adventitia and completely acellular. The elastic fibers were well preserved, and here and there were spread apart by extravasations of erythrocytes. The

adventitia was broad and composed of dense hyalinizing fibrous connective tissue and young adipose tissue cells with focal infiltrations of erythrocytes, lymphocytes, plasma cells, large mononuclear cells, and some giant cells of the foreign body type.

Preparations from the distal (iliac) anastomoses disclosed changes somewhat similar to those at the proximal (aortic) anastomoses. The intima consisted of a layer of fibrin that covered the suture material and extended onto the graft and the host iliac arteries for varying distances. A few scattered cell nuclei were seen in the intima near the anastomoses. Since the lumens of the host iliac arteries had been restored by endarterectomy, the wall of these vessels consisted of the outer portion of the media and the adventitia.

Homografts 70 and 360 Days Old.—The 70-day-old graft had been preserved by freeze-drying and the 360-day-old graft by refrigeration in balanced salt solution (Table, Cases 9 and 10).

Grossly, the graft 70 days old had the usual texture, but its color was somewhat lighter than normal. Host tissues were adherent along the entire length of the graft. The luminal surface of the graft was smooth and contrasted sharply with the irregular surface produced by the atheromatous change in the host aorta. The proximal anastomosis was well healed. Black silk sutures were visible in places beneath a thin transparent layer. The distal anastomoses were intact, but here the sutures were plainly visible and healing appeared to be less complete than at the proximal suture line. The host iliac arteries were thin-walled because of endarterectomy at operation.

Microscopically, the proximal anastomosis revealed extensive sclerotic changes in the intima and media of the host aorta. There was neither eversion nor straight apposition of the graft and the host aorta but, rather, a bulbous enlargement of each end. The media of the host aorta was reduced to less than half its original width. In the adventitia there were abundant coarse collagenous bundles forming a broad band almost equal in width to the entire thickness of the wall of the aorta. In the media and adventitia of the host aorta, giant cells of the foreign body type were noted about the suture material. Along the outer border of the media, there was a broad band of apparently newly-formed, dense, hyalinizing, fibrous connective tissue. In the adventitia near the suture lines, there were abundant focal infiltrations of lymphocytes, plasma cells, and large mononuclear cells. The cleft at the anastomosis was filled with coarse collagenous bundles containing sparse cell nuclei. At the anastomosis the intima of the graft was composed of collagenous bundles containing occasional cell nuclei and was continuous with the wedge-shaped plug filling the cleft (Fig. 7). Toward the graft the fibrillar intima blended into a thin fibrin layer. The media varied in width and was composed of amorphous wavy fibers with no cell nuclei discernible. The adventitia of the graft near the anastomosis was about four times the width of the intima and media. It was composed of coarse collagenous bundles containing aggregations of lymphocytes in places amounting to lymph follicles, various-sized blood vessels, and nerve bundles. Scattered groups of giant cells of the foreign body type contained doubly refractile (suture) material. Between the coapted ends of the graft and the host aorta, delicate wavy collagenous fibrils coursed perpendicularly to the intimal surface.

Near the center of the graft, the intima was composed of a layer of fibrin resting on the elastic fibers of the acellular media (Fig. 8). The adventitia consisted of

coarse collagenous bundles and adipose tissue containing blood vessels and nerves. There were abundant infiltrations of lymphocytes, plasma cells, and large mononuclear cells.

Grossly, the graft 360 days old appeared normal, with its diameter unchanged. It was less pliable than younger transplants but not rigid. The proximal anastomosis to the host aorta was absent because the graft had been removed surgically distal to that point. There was a suture line 1.5 cm. from the proximal end of the specimen that represented the site of excision of a short segment of graft at the time of the original operation. This afforded opportunity to observe the changes in a graft-to-graft anastomosis. The transplant was surrounded by dense fibrous connective tissue that obscured the suture lines. The luminal surface was smooth, with no evidence

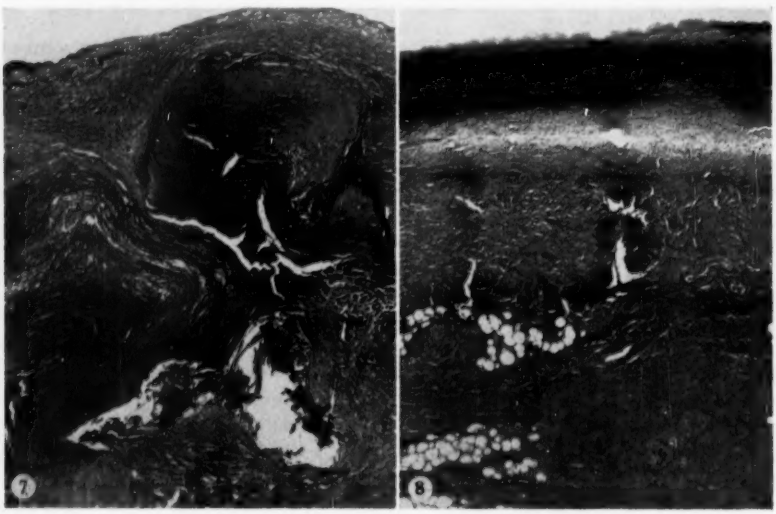


Fig. 7.—Proximal suture line of the 70-day-old homograft. Hyalin connective tissue fills the cleft and surrounds suture material. Graft is on the left. Trichrome preparation × 12.

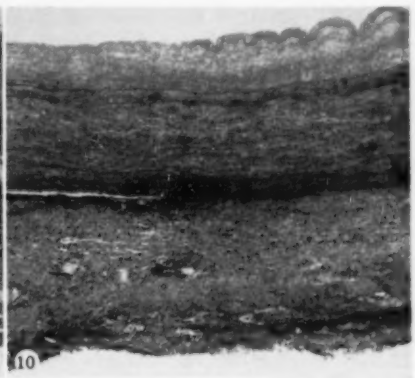
Fig. 8.—Microscopic appearance of the 70-day-old homograft at about its midportion. Intima consists of a narrow rim of fibrin resting on elastic fibers of the acellular media. Adventitia is broad and consists of coarse collagenous bundles and some adipose tissue cells. Weigert preparation × 12.

of thrombosis. The proximal (graft-to-graft) anastomosis was well healed, and no sutures were visible on its inner surface. At the right iliac anastomosis both graft and host artery were constricted and the lumen of each was occluded.

Microscopically, the graft-to-graft anastomosis was marked by a plug of amorphous material that filled the cleft (Fig. 9). The wedge extended outward where it was adjacent to nerve bundles and a large sympathetic ganglion. On both sides of this anastomosis the structure of the wall of the graft was similar. The intima consisted of many fibrils that were loosely arranged near the surface and compact near the media, from which they seemed separated by a distinct elastic lamina (Fig. 10). The media was about three times the width of the intima. It was composed of elastic fibers with no evidence of fragmentation. In its outer third the media

contained connective tissue, blood vessels, and nerve bundles. Extravasations of erythrocytes were noted between adventitia and media (Fig. 11). The adventitia was about twice the combined width of the intima and media and consisted of connective tissue and adipose tissue containing blood vessels and nerve bundles. No retrogressive, atherosclerotic, or calcific changes were noted in the graft.

At the distal (iliac) anastomosis, the intima of the graft was composed of a fibrillar substance of varying width bordered externally by a clearly-discernible, wavy, elastic lamina. The inner third of the graft media contained no cell nuclei near the anastomosis. Between media and adventitia of the graft were streaks of



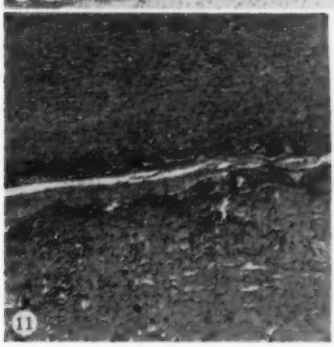


Fig. 9.—Microscopic appearance of the graft-to-graft anastomosis of the 360-day-old graft. Cleft is filled by scar tissue which extends outward into the adventitia.

Fig. 10.—Microscopic appearance of the 360-day-old homograft shown in Fig. 9. Intima is composed of faded elastic fibers and is clearly delimited from the acellular media. In the media the elastic fibers are intact. Weigert preparation × 12.

Fig. 11.—A part of the 360-day-old graft shown in Fig. 10. Areas of extravasation of erythrocytes and fibrin are seen along the media and adventitia. Hematoxylin and eosin preparation × 32.

extravasated erythrocytes. The intima of the host vessel contained globular and slit-like spaces in an amorphous substance. In the media there were calcium deposits. There was marked cellular reaction about the suture material in the adventitia, but in the media and intima no reaction was noted. The suture material near the luminal surface was covered by a pink coagulum.

COMMENT

Morphologic studies of 10 human aortic homografts permit chronologic reconstruction of the changes as they evolve after transplantation. At the time of implantation the graft has no intima; the media is acellular, and only its elastic fibers are intact. Within two days the luminal surface becomes partly covered with a thin layer of fibrin, and the anastomoses are sealed by a fibrin clot that fills the cleft at the

coaptation of the vessels of host and graft. When the graft is seven days old, inflammatory cells are noted in the adventitia. By the 22d day, organization of the fibrin deposits at the anastomoses is evident; there is cellular infiltration about the suture lines, and new connective tissue has formed in the adventitia. For the first time, collections of erythrocytes appear in the media between the elastic fibers.

By the 40th day, there is connective tissue with collagenous bundles between the host aorta and graft indicating healing of the anastomoses by scar tissue. The fibrin wedge at the anastomosis is replaced by young connective tissue that covers the suture material, and organization of the adjacent fibrin layer lining the graft has begun. Toward the center of the graft, elastic fibers of the media form the luminal surface of the graft in some places, while elsewhere a layer of fibrin forms an intimal coat. No nuclear staining is evident in the media, but the elastic fibers are well preserved. The adventitia is broadened by newly-formed connective tissue with coarse collagenous bundles and adipose tissue.

In the graft 70 days old, healing of the anastomoses by scar tissue is complete. Organization of the intima has progressed further toward the center of the graft. As in the younger transplants, the elastic fibers of the media form the inner surface of the graft in many places. The media is narrower, and in its outer margin hyalinizing fibrous connective tissue is noted. Extravasations of erythrocytes between elastic fibers of the media are prominent. The adventitia is broad and composed mostly of collagenous bundles.

In the graft 360 days old, virtually a new vascular conduit has been formed. The scar tissue at the anastomoses is dense. The inner surface of the graft is covered by fibrous connective tissue for a distance of about 3 cm. from the anastomosis. Toward the center of the graft, the intimal layer is composed in places of a pale fibrillar material which is sharply delineated from the media by a distinct elastic lamina. Elsewhere, this fibrillar intimal layer is lacking, and the inner surface of the graft is formed by the elastic fibers of the media itself. The media is composed of fibrous connective tissue hyalinized in its outer third. The elastic fibers appear well preserved, and there is no evidence of fragmentation. Collections of erythrocytes are still noted between adventitia and media. The adventitia is almost twice the width of the media and is composed of dense hyalinizing fibrous connective tissue and newly-formed blood vessels and some nerve bundles. The blood vessels extend inward into the outer portion of the media. No retrogressive changes are noted in the 360-day-old graft.

It appears that the human homograft eventually loses much of its structural identity after transplantation and is in part replaced by fibrous connective tissue of the host. The process of "connective tissue reviviscence" [11] has been repeatedly observed in experimental homografts and probably represents an adaptive response of the host to homologous tissue. This process begins soon after transplantation and is complete at one year. During the period of replacement the elastic fibers of the media maintain the functional integrity of the graft. Indeed, it is this structural element alone that makes feasible the use of arterial homografts in bridging vascular defects. When the elastic fibers are not preserved, as in heterografts, aneurysmal dilatation and rupture of the graft occur.[3]

Although the morphologic changes occurring in human homografts generally parallel those observed in experimental transplants, several differences have been noted. In the dog homograft, an entirely new intima is formed in the layer of fibrin

that covers the entire inner surface of the graft. In the human homograft, a similar deposit of fibrin is seen in some places. Organization of this layer is noted near the anastomoses as early as the 22d day. Elsewhere, however, the fibrin layer is lacking, and the inner surface of the graft is formed by exposed elastic fibers of the media. This is well demonstrated in the 360-day-old graft in which near the proximal (graft-to-graft) anastomosis a distinct intima is not seen but the inner elastic fibers of the media are compressed to resemble a separate layer. The presence of red blood cells between the elastic fibers of the media has not been recorded in experimental homografts. The origin of these erythrocytes is not entirely clear. Apparently the minute hemorrhages come from rupture of newly formed capillaries that penetrate the media from without. Collections of erythrocytes and fibrin probably provide nutritional stimulus to nearby fibroblasts.

Until recently, excision of segments of the aorta with homograft replacement for aneurysms or thrombo-obliterative disease was not attempted. Reluctance to employ this form of therapy was due in part to the belief that atherosclerotic changes in the vessels of the host would preclude satisfactory healing along the lines of anastomosis. The healing between host vessels and graft demonstrated in this study indicates that this assumption was erroneous.

SUMMARY

Morphologic studies were made from 1 to 360 days after transplantation on 10 human aortic homografts. The results indicate that the human homograft loses much of its structural identity after transplantation and is in part replaced by fibrous connective tissue of the host. Minute hemorrhages occurring in the media from rupture of newly formed capillaries apparently provide the nutritional stimulus to the formation of new connective tissue. The elastic fibers of the media remain intact and support the graft during the period of connective tissue growth reinforcing the graft from the outside. Satisfactory healing occurs at the anastomoses in the presence of extensive atherosclerotic changes in host vessels. No retrogressive changes, atherosclerotic or calcific, were noted in one graft 360 days old.

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FURTHER EXPERIENCES WITH TRACHEOTOMY IN MANAGEMENT OF CRUSHING INJURIES OF CHEST

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AND
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FIVE YEARS ago a tracheotomy was performed "out of desperation" on a patient in the Cincinnati General Hospital who was practically moribund as the result of a crushing injury of the thorax. When the operation was performed, this obese patient was having labored, painful, and shallow respirations; he was deeply cyanotic and extremely apprehensive and evidenced striking paradoxical movements of his injured anterior thoracic wall. Almost immediately after the operation, his respirations became slower and much less painful, his color improved rapidly, his anxiety disappeared, and, what was remarkable to all observers, the paradoxical movements of his chest wall practically ceased. All these phenomena occurred despite the fact that aspiration of his tracheobronchial tree produced little in the way of blood or secretions. To our amazement the patient recovered. This striking result encouraged us to treat subsequent cases of crushed chest by means of tracheotomy on an empiric basis but to attempt to determine by laboratory investigation the physiological mechanisms which were involved.

After considerable investigation both in the anatomical and in the experimental laboratory, the following hitherto unrecognized physiological effects of tracheotomy were determined: (1) a reduction in the volume of the "dead space" involved in the respiratory act, and (2) a decrease in the resistance to the inspired and expired air. The "dead space" comprises the volume of air occupying the nose, throat, pharynx, larynx, and portions of the trachea and normally measures about 150 cc. When the point of entrance of the inspired air is shifted by tracheotomy to a site just above the suprasternal notch, 100 cc., or two-thirds of the anatomical dead space is eliminated. It must be remembered that the air which occupies this dead space, though it is a portion of the tidal air, does not contribute to ultimate oxygenation but nevertheless must be moved to and fro with inspiration and expiration. Thus the tracheotomy relieves the impaired respiratory mechanism of a considerable work load by eliminating a large proportion of the dead space. Most importantly, it permits more effective utilization of the tidal air, which in cases of severe chest injury has been reduced to alarmingly low levels. Two important principles of gas flow in tubes are (1) that the resistance to flow varies inversely with the diameter of the tube and (2) that resistance varies with turbulence. In deference to the function of phonation, man's larynx is considerably narrowed and actually is a bottleneck

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in the respiratory passages. In addition, the many convolutions in the nose, mouth, pharynx, and larynx are particularly suited to produce turbulence. It is, therefore, readily understandable how tracheotomy by by-passing these areas produces a decreased resistance to the inspired and expired air.

In 1951, we reported six cases of serious crushing injuries of the chest which had been treated by tracheotomy. There were two deaths in this series. One of these was considered to have resulted from associated severe head injury and the other from too long delay in performing the operation. In each of these two cases, however, marked improvement in respiration resulted after tracheotomy. Again, in January, 1953, we reported on this subject and added six more cases. All these patients responded dramatically to the operation. One of them died as a result of massive hemorrhages from a duodenal ulcer on his 10th hospital day, by which time his respiratory symptoms had long since disappeared. Since this last report 28 additional cases have been treated by tracheotomy. All of these had severe crushing injuries of the chest with multiple segmental rib fractures. During this same period, 17 patients with less severe crushing chest injuries were seen for whom tracheotomy was not considered to be indicated. With this background of clinical experience it seemed worthwhile to comment further on this method of treatment, stressing certain points and indicating the dangers and the complications which have been encountered.

Tracheotomy should be performed immediately on those patients who, when first seen, present the classic signs and symptoms of a severe crushing injury of the chest. Among the more important of these are the physical signs of extensive rib fracture with paradoxical movements of the loose segment of the thoracic wall, dyspnea, cyanosis, painful and short respiration, apprehension, and inability to raise accumulating secretions from the bronchi. Immediate tracheotomy was performed 24 times in our series of 40 cases. There are, however, a considerable number of patients with extensive chest injuries who at first will fail to show the above signs and symptoms. Under close and careful observation as time goes on, they will begin to evidence certain findings which presage impending disaster. These telltale findings are an increase in the rate of respiration; more painful and shallower respirations; accumulation of secretions in the tracheobronchial tree which cannot be cleared; increasing cyanosis, restlessness, and fear, and evidence of early paradoxical movement of the injured segment of the chest wall. We have learned that it is imperative to perform tracheotomy as soon as these evidences of progressive respiratory imbalance appear. Sixteen such cases were encountered in this series, and in 5 of these the tracheotomy was performed after a lapse of 24 hours. One death in our first series resulted from too long a delay in performing tracheotomy, and in two other patients in the earlier series disaster nearly resulted from the same cause. In our opinion it is far preferable to perform the operation too early rather than to risk a too long delay. The physiological effects of crushed chest can become irreversible but a properly-timed tracheotomy is the most effective means we know of breaking the vicious cycle of the "wet lung," which leads to death from anoxia, and of combatting certain factors which operate to reduce the respiratory reserve. These latter are (1) the paradoxical movement of the chest wall which interrupts the efficiency of the respiratory act; (2) the severe pain arising from the movement of the fractured ribs, which further impairs attempts at increased respiratory effort, and

(3) the copious tracheobronchial secretions which may result immediately from parenchymal injury of the bronchi or lung or may develop later in the wet lung syndrome.

With an increasing experience in the management of patients with crushed chests has come the realization that constant consideration must be given to severe associated injuries resulting from the trauma responsible for the chest injury. In our series of 40 cases of severe crushing injuries of the chest 28 had associated injuries of considerable magnitude. Fifteen had head injuries, the significance of which is attested by the occurrence of four deaths in this group. Fractures of one or more extremities or of the bony pelvis occurred in 19 patients. The incidence of intra-abdominal injury was surprisingly low, only one patient being subjected to celiotomy. He was found to have a retroperitoneal hematoma without perforation of a hollow viscus. There were no instances of ruptured spleen, torn diaphragm, or perforated viscus, but such conditions would almost certainly appear in a series of cases larger than the one reported. Equally important is the necessity to recognize the multiplicity of thoracic complications which may accompany the skeletal injury to the thorax and which require supplementary therapeutic measures. Neglect of these complicating factors may well mean the difference between failure and success. Such complications are frequent and consist of hemothorax, simple or tension pneumothorax, progressive subcutaneous emphysema, and bleeding into the tracheobronchial tree. We place great reliance on early simple aspiration of the pleural cavity. The evidence thus obtained is definite, and this procedure obviates the necessity of moving a critically ill patient for x-ray studies. Spreading subcutaneous emphysema or rapidly accumulating pneumothorax with or without tension has been effectively managed by the introduction of a small catheter into the pleural cavity and attaching it to a water seal. In 23 of our cases pneumothorax was encountered, and in 13 of these the use of an intrapleural water-sealed catheter was indicated. Hemothorax was present in 14 cases. It was usually small or moderate in amount and exceeded 500 cc. in only three instances. Satisfactory response to repeated aspirations was obtained in all cases of hemothorax. No proved instance of contusion of the heart has been encountered, though its possible occurrence has been constantly borne in mind.

There have been 12 deaths in the series of 40 patients treated by tracheotomy. A review of these indicated that four deaths were due to severe associated head injury; two deaths resulted from fat embolism proved at autopsy; one death was caused by a massive hemorrhage from a bleeding duodenal ulcer 10 days postoperatively; two deaths were due to shock which produced a lower nephron nephrosis (proved at autopsy) in one case and was irreversible in the other, the patient dying two hours after admission; two deaths which occurred suddenly on the third postoperative day were thought to be due to pulmonary embolism, though no autopsy was obtained, and one death resulted from a failure of response to tracheotomy. The last-mentioned patient was a 50-year-old Negro who had fractures of the third through eighth ribs bilaterally and parasternally. He had marked paradoxical respirations with severe cyanosis and widespread subcutaneous emphysema. There were no associated injuries. Immediate tracheotomy was followed by little response, and the paradoxical movements persisted unchanged. Skeletal fixation of the flail-

like sternum was likewise unsuccessful, and the patient died on the day of admission. In every case but this one the response to tracheotomy was good and in the majority was dramatic.

All the tracheotomies have been of the low variety and performed with local anesthesia without moving the patient from his bed. A hard pillow or sandbag placed under the patient's shoulders aids in hyperextension of the neck, which, in turn, makes the trachea more accessible and permits a low tracheotomy to be more easily performed. The usual care of the tracheotomy tube has been exercised. It is important to remember that, since the glottis has been defunctionalized by the tracheotomy, the patient is unable to cough effectively. Consequently, at first the tracheobronchial tree must be aspirated at frequent intervals, depending on the amount of secretion present. Subsequently only an occasional aspiration is required. Aspiration through the tracheotomy tube is not without danger. If it is continued too long at a time, the oxygen concentration in the arterial blood may become lowered precipitously and anoxia may occur quickly. Under such conditions the vagovagal reflexes are encouraged, and the stimulation of the aspirating catheter may cause cardiac arrest. We have seen one such instance, though it was not in a patient with a crushed chest. For these reasons, aspiration through the tracheotomy tube must be performed carefully and only for short interrupted periods. There has been no definite time set for removal of the tracheotomy tube, though the usual time has been about two weeks. The tube was removed as early as the 5th day in our series and as late as the 27th day. It should be left in until there has been such fixation of the rib fractures that the paradoxical movements of the chest wall do not reappear. As stated previously, all tracheotomies were of the low variety and none have been followed by complications such as stenosis of the trachea, hemorrhage, or spreading infection.

In an effort to evaluate the extent of the use and the usefulness of tracheotomy in the management of patients with crushing injuries of the chest, personal letters were written to several thoracic surgeons in various parts of the United States. Abstracts and quotations from replies to these letters follow.

Dr. Paul C. Sampson, Oakland, Calif., has used tracheotomy in approximately 25 cases of "chest injury." Does not limit its use to crushing injuries of the chest but believes it is indicated in any chest injury which results in severe pulmonary contusion and persistence of "traumatic wet lung." Feels that the procedure is very valuable. Emphasizes the usefulness of continuous oxygen aerosol mixtures in the management of the tracheotomy postoperatively.

Dr. Osler Abbott, Atlanta, employs tracheotomy chiefly for the maintenance of a clear airway in patients with chest injuries, particularly those with associated head injury. For the patients with severely crushed chest and segmental rib fractures uses the Drinker respirator.

Dr. Brian Blades, Washington, D. C., has used tracheotomy in three cases of severely crushed chest and feels that it is life-saving.

Dr. Duane Carr, Memphis, has employed the procedure in about 15 cases of crushed chest. States that he believes it is excellent, necessary, and a life-saving measure.

Dr. George Minor, Charlottesville, Va., has done tracheotomy on very few patients with crushing injury of the chest but feels it is an extremely useful procedure and plans to use it more frequently in the future.

Dr. William Tuttle, Detroit, has used the procedure in only one case. Feels that it is good but does not consider it a panacea and believes that "tried and proved measures still should be used."

Dr. Rollin Daniel, Nashville, Tenn., has employed tracheotomy in five out of eight cases of crushed chest. Two of these five died, one from a head injury and one from fat embolism. Feels that tracheotomy was beneficial to all cases.

Dr. Cameron Haight, Ann Arbor, Mich., "I believe it is a life saving measure in a certain number of cases, and we find we are using it with increasing frequency. This particularly applies to patients with injuries in addition to those of the chest, notably those patients with associated head injury."

Dr. Robert Shaw, Dallas, Texas, "We have used tracheotomy practically routinely in the treatment of crushed chests." He has had experience with the procedure in 16 cases. Two of these died, one from a head injury, and one from a combination of a torn diaphragm and multiple extremity fractures.

Dr. Julian Johnson, Philadelphia, has treated approximately six patients with crushing injuries of the chest by tracheotomy. "I believe that tracheotomy is frequently a life-saving measure and we have come to use it quite freely, not only in crushing injuries of the chest but in many other conditions."

SUMMARY

The results following the use of tracheotomy in the management of 40 patients with severe crushing injury of the chest are reported, and the experience with the procedure by 10 thoracic surgeons is outlined. These data indicate that tracheotomy is a useful and often a life-saving measure in the treatment of such patients.

TREATMENT OF SPINAL CORD INJURIES

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> With the rule of right and wrong given us by Christ, there is nothing for which we have no standard. And there is no greatness where there is not simplicity, goodness, and truth.
>
> "War and Peace"—Tolstoy

IN THE year 1946, in planning the organization of the treatment of patients with injuries of the spinal cord and cauda equina in the first Veterans Administration Hospital to be administered by a university dean's committee, it was decided that these patients were properly the responsibility of the department of neurology. Consultants in neurological surgery, general surgery, medicine, and physical medicine were appointed to this service. Each, with a staff of residents and attending surgeons, was responsible for the problems in that particular specialty which arose among these patients.

Since then, 1,242 patients with injuries of the spinal cord or cauda equina have been treated upon the special wards set aside for these patients. I wish to relate a fragment of the observations and experience of all of the consultants and physicians who have been associated in the treatment of these patients, and to that end I have drawn freely from their published observations. A large number of intensive studies have been carried out upon small groups of patients selected for the investigation of some particular subject, such as spasms, reflex activities, pain, recovery of bladder and rectal function, nutrition and bodily function, fractures, decubitus ulcers, problems of physical medicine, and the follow-up studies of discharged patients by social service.

Many veterans have sustained injuries to the spinal cord and cauda equina in civilian life and have been transferred from civilian hospitals soon after their injuries to these wards. It has been possible, therefore, to make a comparison of the evolution of the signs, symptoms, and complications of these injuries between those sustained in civil accidents and those injured during war and treated under the often-unavoidable, adverse conditions of military practice. Obviously, many differences were found in relation to mortality, morbidity, and complications. Recently, we have been able to study patients with injuries sustained in the Korean War and to compare the residuals of these injuries with those sustained in World War II.

The opportunities for clinical investigation of every aspect of the injuries suffered by these patients has been unlimited, and this group constitutes one of the largest group of patients with spinal cord injuries ever studied. Perhaps, in some small way the application of these observations and studies to future patients so

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unfortunate may compensate for the suffering, terrible loss of manpower, financial waste, and the dislocation of economy which we have suffered through three World Wars.

GENITOURINARY COMPLICATIONS

Treatment of the urinary bladder in injuries of the spinal cord cannot be described categorically. Genitourinary complications succeed one another during the life of the patient, who must be reexamined at regular intervals so that the method of management may be changed in accordance with the indications at a given time.

During the acute phase of the spinal cord injury, stasis infection must be prevented. This is best accomplished by urethral catheter drainage and the proper antibiotics or urinary antiseptics. Acid-ash diets combined with acidifying diuretics aid in combating the colioform infections as well as keeping alkaline salts in solution or suspension. During this state, there is considerable mobilization of calcium in the blood stream and the excess is excreted by the kidneys. Proper drainage, acidification of the urine, and diuresis aid in the prevention of calculi which form in the upper urinary tract.

A true evaluation of the possibility of return of bladder function can be ascertained only after the acute stage of the spinal cord injury has passed and an accurate determination of the degree of permanent damage in the spinal cord can be established. Each patient should be tested to determine whether he can empty his bladder by the use of external reflex stimuli, manual pressure upon the abdomen, and the use of secondary urinary muscles. If the residual urine obtained is less than 100 cc., the patient should be considered to have an automatic, or a normally functioning, bladder, but residuals above that amount should be considered evidence of a neurogenic bladder and an indication for further catheter drainage. Repeated tests of ability to empty the bladder should be carried out periodically. Tidal drainage equipment is a valuable aid toward the early development of an automatic bladder.

If it is impossible to establish an automatic bladder, then the decision must be made as to the best permanent type of drainage—that is, suprapubic or urethral catheter drainage. Many complications have been encountered with urethral catheter drainage, such as epididymitis with orchitis, abscess of the prostate, seminal vesiculitis, periurethral abscess, and diverticula of the urethra with infection.

Automatic bladder function developed more frequently in patients with incomplete lesions than those with complete lesions of the spinal cord. It appeared that the lower the lesion, the earlier the development of automatic function, which is very unstable and can readily be disturbed and may disappear in the presence of complicating genitourinary infections and other diseases of the body.

Some evidence of the success of management of the genitourinary tract in these patients may be reflected from a comparison of the incidence of infections, stones, and the necessity for cystoscopy. In 1946, of the patients, 53.8% suffered from serious cystitis; in 1950, the percentage had dropped to 45. Thirty-five per cent of the patients in 1946 had bladder stones; in 1951, this percentage had dropped to 8.7%; 224 cystoscopies were performed in 1946 and 99 in 1950.

Many of these patients die of diseases of the genitourinary tract, and others, when the body is insulted by disease or trauma elsewhere, succumb to uremia, which otherwise would not have occurred. Therefore, the most important principles to

be followed in the treatment of the genitourinary tract are the control of infection, the development of an automatic bladder, bladder training, and the regulation of water intake. It should always be remembered that the bladder is a social convenience but the kidneys are essential for life.

BOWEL CONTROL

As it is with the bladder, so it is with the bowel after injury to the spinal cord, voluntary emptying is impossible. The state of bowel action depends a great deal upon the consistency of the stool. When it is formed and by long retention becomes dehydrated and hard, obstipation or retention occurs. When, for some reason, loose stools are present, incontinence occurs. In a comparison of the tonicity of the external sphincter muscle, it was found that 40% of the patients with war spinal cord injuries had a tonic external sphincter and 80% of the patients who suffered from civilian spinal cord injuries had a tonic sphincter. In lesions of the cervical portion of the spinal cord, the external sphincter was spastic in both groups in about 90% of the patients; with lesions of the lower thoracic region it was spastic in 30% of the war injuries and 75% of the civilian injuries. In lesions of the lumbar cord and cauda equina, spasticity appeared in a smaller number, about 23%. At a variable period after injury, there was a relaxation of the tonicity of the external sphincter. Again, like the bladder, reflex emptying may become possible in the bowel. It becomes possible with injuries of the spinal cord in which a reflex contraction of the bowel musculature occurs and relaxation of the sphincter permits an evacuation and with the lesions of the cauda equina in which an axon reflex produces contraction of the bowel musculature and a flaccid external sphincter allows the contents to escape.

Many other distressing signs and symptoms occur as the result of poor bowel evacuation. This is particularly true of the patients with lesions in the cervical and upper thoracic portions of the spinal cord, in whom the increased autonomic reflexes result in hypertension, headache, profuse sweating of the face, chills, dizziness, and, in many, loss of consciousness. Nausea, and at times vomiting, abdominal discomfort, anorexia, and an increase of muscular spasms and of burning pain were common to all levels of lesions. Accordingly, a program was instituted to teach the patients to accomplish emptying of the bowel first by reflex evacuation, with the later development of autonomic function.

From a large number of barium-meal studies, it was learned that there was no impediment to the flow of barium as far as the large bowel in these patients. From studying the retention of charcoal meals, it was obvious that there was a great delay in the passage of the stool along the course of the large bowel, as well as the rectum, and that after the first appearance of charcoal, a number of days could elapse before it completely disappeared from the stool. It was planned, therefore, to develop reflex defecation first by stimuli designed to stretch the anus produced by the patient's finger, wearing a rubber cot.

It was found after a great deal of experimentation that, in order to initiate a successful bowel control program, lectures had to be given to the attendants, nurses, and patients on the anatomy and physiology of the bowel. In those patients who had taken enemas for many months, there was at first a sluggish or no response to rectal stretching. However, as the tone of the rectal muscles returned, the patient found greater ease in producing a bowel movement and less time was needed to

stimulate contraction. The patients were encouraged to use their abdominal muscles, to strain moderately, or, if these muscles were paralyzed, to utilize manual pressure in association with the diaphragm to increase intra-abdominal pressure. As these manipulations became more efficient, many of the patients induced bowel movements merely by touching the area of the anus and then gradually discarded the external stimulus as they acquired automatic defecation with the help of mild to moderate straining.

A comparison of the results of bowel training in war and civilian-injured patients in general suggests that reflex evacuation is easier to effect when longer periods since injury have elapsed, except in those patients with injuries of the low thoracic and lumbar regions of the cord and of the cauda equina.

DECUBITUS ULCERS

By some, decubitus ulcers are considered to be of neurogenic origin and by others due solely to trauma of the skin. The truth is probably between these two extremes. It is well known that deep necrotizing ulcers which destroy tissue to the bone may occur during the first week after injury to the spinal cord. On the other hand, it has been demonstrated clearly that excellent nursing care with frequent turning of the patient, proper padding of weight-bearing areas, and careful attention to skin hygiene, as well as maintenance of the patient's nutrition, have resulted in the prevention of decubitus ulcers in patients so treated properly from the time of the occurrence of their spinal cord injury.

Even before there has been a breakdown, there is evidence of damage to the skin and the underlying tissues, consisting of discoloration, edema, and induration. Small vessels are thrombosed; venules are engorged, and the arterioles of the skin are thickened. If the patient is not moved to reduce the pressure on this area, the skin breaks down and a well-established ulcer appears. At first, there is a necrotic slough, which at first is adherent and then begins to separate, accompanied by a foul exudate. Surrounding the ulcer is a zone in which the tissue cells are dead or dying, and peripheral to this zone is one varying in size in which the cells have been injured and will die unless the factors responsible for their injury cease to act. Ulcers which show no tendency to heal under conservative treatment should be radically excised, the excision including the underlying bone. Closure should be effected by primary approximation, or by rotation of flaps and skin grafting. Many decubitus ulcers recur when patients are discharged from the hospital because of carelessness on the part of the patient, trauma from accidental friction, and abrasion due to the implements used in daily living.

During World War II and immediately afterward, numerous extensive decubitus ulcerations were accepted as an unavoidable exigency of war, but now the admission of one or two patients with signs of evident neglect is unusual. None of the huge undermined ulcers which occurred in the patients with spinal cord injuries in World War II have been seen among the patients received from the Korean battlefront.

MOTOR SYMPTOMS

One of the most important lessons has been learned from a study of this large number of patients with spinal cord injuries which should be emphasized again and again for the benefit of the physician who sees these patients early after their

injury. This is, that anatomical section of the spinal cord cannot be differentiated from a physiological interruption of function by the character of the reflexes or the posture of the paralyzed extremities.

Immediately after injury of the spinal cord, a state of spinal shock occurs which is characterized by a disappearance of all reflex activity below the point of the injury. This state may persist for several days or weeks, following which there is a return of reflex activity in the isolated portion of the spinal cord. Early in the course of recovery from spinal shock there may be a diffuse and vigorous response to any noxious stimulus, such as pinching or pricking of the skin, below the level of the lesion. This response has been termed a mass reflex and consists not only of strong reflex movements in the lower extremities but also of autonomic responses, such as evacuation of the full bowel or bladder and profuse sweating below the level of the lesion. After recovery from the initial state of areflexia, the isolated portion of the spinal cord develops an autonomous function. Reflex action of a diversified nature gradually evolves and achieves an individuality which varies from patient to patient. These responses are induced by such simple stimuli as a gust of air, contact with the bed sheet, passive stretching of the limb, a full bladder, or a full bowel.

Spasms are common, troublesome complications of spinal cord injuries, and the term is often loosely used to denote any involuntary movement of the extremity. Most often spasms are manifested by movements of flexion at the hip, knee, and ankle of varying intensity; by movements of extension at the same joints, and frequently by vigorous adduction of the thighs. Often spasms of a distressing nature frequently occur in the muscles of the abdominal wall and viscera, especially in the urinary bladder. They appear to occur spontaneously but usually they are the result of stimulation from obvious external and internal sources. Spasms constitute a serious disability, not only because they produce discomfort to the patient but because they interfere with the healing of decubitus ulcers, care of genitourinary tract complications, and they may lead to dislocation and fractures of bones and interfere with rehabilitation.

The incidence of spasms varies in relation to the segments of the spinal cord affected by the injury. They have been found to be present with all lesions of the cervical portion of the spinal cord, with from 75 to 85% of all thoracic spinal cord lesions, with 31 to 40% of lumbar lesions, and with 30% of lesions in the conus and cauda equina. They do not occur with uncomplicated lesions of the cauda equina. They begin, increase, and reach a peak which is maintained and then in a great number of cases diminish in severity if not in frequency. No medication has been found of any real value in diminishing the frequency or severity of these spasms despite reports elsewhere to the contrary.

Therefore, section of the obturator nerves and rhizotomy have been performed. If the rhizotomy is successful, the increased reflex activity is abolished. However, once anterior rhizotomy is carried out, the patient can never have any useful return of motion. Unless the lesion was proved to be anatomically complete, rhizotomy has been done only on rare occasions when it would be a life-saving procedure.

PAIN

Patients with spinal cord injuries often suffer from two types of pain. That type which is referred distally from lesions of the spinal roots at the level of the injury

is well known because it occurs in other diseases. Likewise, the surgical methods of its relief are well understood. However, there is a type of pain which occurs in that portion of the body below the level of the lesion of the spinal cord which is diffuse, imperfectly localized, and is described by the patient as burning, tingling, stinging, aching, a pins-and-needles sensation, or sharp and shooting. The localization varies considerably in a given patient and it is felt diffusely in the soles of the feet, both lower extremities, the abdominal wall, or only the lower portion of the abdominal wall. Soon after the injury the pain may be sufficiently intense so that the patient complains bitterly and begs for relief. Early in our experience with these patients, narcotics and other drugs had been given to them freely elsewhere and in the majority of instances ineffectually, to the point of producing addiction. Various surgical procedures had been performed before they came under our care for the purpose of interrupting neural pathways that might transmit these painful stimuli to the brain. In several instances, cordotomies were performed with the production of a complete anatomical section of the spinal cord above the level of the original injury, with no relief of the pain.

We had observed in several instances that a patient with a spinal cord injury may have also had an amputation of one lower extremity but that he experienced not only the existence of the amputated lower extremity, often describing its position, but he also suffered from this burning type of pain in the amputated extremity. This, of course, suggested that there could be no centripetal impulses from the amputated limb which could give rise to such a sensation. It was also found that this diffuse burning pain was unaffected in the presence of a spinal anesthesia below the level of the spinal cord injury, which interrupted any centripetal fibers through the posterior roots into the spinal cord. However, if the distal end of the proximal segment of the injured spinal cord was anesthetized by spinal anesthesia, the pain disappeared. This suggested that the origin of this pain was the end of the proximal segment of the injured spinal cord and that posterior root sections or operations upon the sympathetic nervous system would be ineffectual.

In 1947, this type of diffuse pain was noted as a spontaneous complaint in 82% of the patients. As time passed by, it receded from the consciousness of the patient and was complained of spontaneously by only 40 of 217 patients. At present it is rare to find a patient with severe distal pain of this type, and the postponement of surgical procedures for its relief has been justified, in our opinion, by the development of a higher threshold for this type of pain.

RECOVERY OF FUNCTION

The possibility of recovery from an injury to the spinal cord is of critical importance in the decision concerning the treatment of management of the patient and in his adjustment to his injury. When there is a paralysis of motion and sensation after a spinal cord injury, no differentiation between a complete anatomical section and a complete physiological interruption of the spinal cord is possible. The only indication for surgical treatment which exists is the relief of a block in the spinal subarachnoid space which can be determined by manometric studies. It is this mechanical interruption of the function of the spinal cord which can be relieved surgically, and only this. Therefore, it is wrong to deny the patient any benefit he may receive from a surgical procedure if an indication exists in the presence of a subarachnoid space block.

Our experiences as far as recoverability in motion, sensation, and other functions of the spinal cord are not in accord with the statement that unless some return is found in the first 48 hours after injury no useful function will occur. We have found it impossible from a study of posture and reflex activities to differentiate an anatomical from a physiological interruption. It is necessary to await some evidence of recovery of motion or sensation.

In a study of 378 patients, Pollock and his colleagues found that some recovery was present in 93 patients; of sensory function in 89 and of motion in 87. Of these 87 patients who recovered motor function, 26% had a slight recovery, 44% a moderate, and 28% a marked recovery. In lesions of the cervical portion of the spinal cord, there was a larger percentage of marked recovery of sensory function than with injuries at other levels.

The earlier the return of function, the more likely it is that there will be recovery and the better the recovery will be. With regard to sensory recovery, the median time for the first return of sensation for the entire group was about three months but the range ran from one week to a number of years. The return of motor function may occur within two months or less, although marked recovery has occurred when the first evidence of its return was as long as five months after injury. Therefore, unless the lesion has been proved to be a complete anatomical section, recovery of motion and sensation may begin months after the injury.

REHABILITATION

Perhaps for psychological reasons, at the end of the war it was impressed upon the veterans with spinal cord injuries that they were disabled only by reason of their inability to walk and that otherwise they could be well and healthy men. In fact, in many instances they were told that they could walk, and this misunderstanding of the veterans' definition of walking and what was actually meant, ambulation, created many difficulties. At any rate, these statements were certainly deceptions.

A well-organized and intensively active program of physical medicine and rehabilitation is one of the most important parts of the management of patients with spinal cord injuries. It contributes to the general and mental well-being of the patient when his treatment may be limited to bed activities. It is of benefit in increasing his appetite, his weight, and general strength; in improving the circulation of his skin; in diminishing genitourinary infection, preventing the formation of stones, and improving bowel action. Of course, nothing contributes more to the morale of the patient than the independence brought about by the teaching of dexterity of movement and the development of strength in unparalyzed muscles.

It is obvious that it is most difficult to accomplish activities in the patient with a lesion of the cervical portion of the spinal cord. It becomes necessary to devise splints, cuffs, enlarged grips, and holding devices, counterbalances, and other aids which may allow such a patient to shave, eat, and wash himself.

Obviously, greater degrees of rehabilitation are possible when the lesion of the spinal cord is incomplete or when there is a lesion of the cauda equina only. It has been found consistently that the earlier the patient is started on a physical medicine and rehabilitation program, the better will be the results and the less the time required to accomplish them. The greatest difference, therefore, between war and civilian injuries is the lapse of time between injury and the institution of this program. In the individual civilian patient, the institution of such a program

requires intensive cooperation on the part of the patient's entire family, often financial means beyond those of the average patient, and always an organization of activities to the end that the patient may be made as independent as possible.

With all these methods of treatment the state of the general health of the patient should never be forgotten and this varies in respect to time, to where the patient is living, and to how he is treated. The patient is a problem involving all fields of medicine and surgery and not one specific specialty. It is my opinion that at no time can a patient with a spinal cord injury be considered to be free from the necessity of good medical care.

The early problems in the treatment of injuries of the spinal cord as the result of World War II were different than those which concern civilian injuries. Patients with the former were returned with anemia, hypoproteinemia, bladder infections, calculi, poorly established bladder drainage, decubitus ulcers, malnutrition, and amyloidosis. These problems required a large nursing and attendant staff. In April, 1946, there were in our Veterans Administration Hospital on the spinal cord injury wards 118 nurses and 179 attendants. In January, 1950, with a census of patients relatively the same there were 44 nurses and 96 attendants. By the end of 1949, only 34% of the patients had sustained injury of the spinal cord as the result of war and the remainder were there because of civilian injuries. The civilian patients had fewer complications, and this accounts, in part, for the decrease in the number of personnel required to treat them.

I deeply appreciate the opportunity which was given to me by the man whom we are honoring today because the experiences gained, I believed, have contributed to whatever state I may have attained in my professional and personal life. It is one thing to outline and carry out the treatment of such a large number of patients with injuries of the spinal cord in a well-equipped fixed hospital unit and another to organize the treatment of such patients immediately after their injury on the battlefield and arrange their transportation quickly and efficiently to a place for continued treatment. One may even find it difficult to be able to write a memorandum of instructions which will satisfy the requirements in English of a fellow doctor who occupies a minor executive position which gives him the power of veto. Certainly, without such an ability, the beginning of the treatment of these patients in a theater of war may become so frustrating as to lead to attempts to accomplish the goal outside the prescribed channels of procedure. I may say for the benefit of those in the future that this is hazardous—to put it mildly.

To only a few men is given the ability to be equally successful in their personal and professional accomplishments in uniform and in civilian clothes. I am proud of Fred Rankin's accomplishments in this respect and would be more than human if I were not envious when I attempt to analyze my own score in these respects.

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CEREBRAL INTRAVASCULAR PRESSURE IN CHEMICALLY INDUCED HYPOTENSION

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PREVIOUS studies have demonstrated the safety and feasibility of measuring intravascular pressure by the introduction of a No. 27 needle, attached to appropriate amplifying and recording devices, into any cerebral vessel. By this means, intravascular arterial pressures have been secured from all components of the anterior part of the circle of Willis, from cortical vessels, and from arteriovenous anomalies. Such measurements have defined the normal intravascular pressure gradient in the carotid arterial tree and, in particular, have developed a method of serial testing at operation for the presence of adequate or inadequate cross-hemispheral circulation—that is, an objective Matas test. Other observations have been made concerning the residual intravascular pressure in components of the circle of Willis and in blind arterial segments following various intracranial and combined extracranial and intracranial clip ligations for the treatment of congenital cerebral aneurysms. Among findings pertinent to the data to be presented was the observation that a residual intravascular pressure of 50 mm. Hg or less in an arterial segment isolated from the homolateral carotid artery represented a critical level at which tissue necrosis might ensue in the human brain.* A number of other studies in this general field are available.†

Since the clinical manifestations of cerebral anoxia have been listed among the complications of chemically induced hypotension,[9] it seemed worth while to extend the technique of measuring cerebral intravascular pressure to a study of patients undergoing hazardous neurosurgical procedures in which induced hypotension seemed indicated. Twenty-six patients were chosen for this study; nine of these were operated upon for the control of congenital cerebral aneurysms and two for arteriovenous aneurysms; large meningiomas were removed from six patients, and lobe resections were performed upon nine patients with gliomas. The considerable

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* References 1-3.

† References 4-8.

value of induced hypotension in the control of hemorrhage in this series of patients has been reported elsewhere [10] and has been reiterated in many neurosurgical papers.

In this series of patients, readings were made of arm cuff pressures and of intravascular radial artery and cerebrocortical artery pressures before and during induced chemical hypotension. No effort was made to correlate the depth of hypotension obtained with the subsequent clinical course of each patient, since it is obvious that no controlled study can be made in this respect in the human. All cortical pressures were obtained through No. 27-gauge needles 4 to 6 cm. in length, converted with a Sanborn electromanometer, and recorded on a Sanborn four-channel amplifier recorder. Appropriate apparatus was used to flush continuously the intravascular needle to obviate the effect of damping. The patients were anesthetized, and arm cuff blood pressure readings were made with a conventional Tycos manometer. A No. 18 needle or a polyethylene catheter was introduced into the radial artery for the continuous recording of the systemic blood pressure. When indicated for the evaluation of resistance across the circle of Willis, intermittent intravascular pressures were recorded from the carotid neck vessels. Cerebrocortical vessels were chosen for study that conformed grossly to the diameter of the recording needle. Certain variations in the data appear to result from this factor as well as from the time lag that might occur between the recordings of arm cuff and intravascular pressures. The data are presented as mean arterial pressures, with the mean arm cuff pressure being calculated from the usual formula, the mean pressure equalling the diastolic pressure plus two thirds pulse pressure.

Hypotension was induced by N,N,N′,N′-3-pentamethyl-N,N′-diethyl-3-azopentane-1,5-diammonium dibromide (Pendiomid ‡) in 16 cases, by hexamethonium chloride in 8 cases and by camphorsulfonate trimethaphen (Arfonad §) in 2 cases. In the course of this study, extreme depths of hypotension were developed inadvertently in some cases; when this was recognized in the intravascular radial artery recordings, it was corrected either by change in body posture or by the use of levarterenol (Levophed). Such extremes of hypotension were of variable duration, measuring from 5 to 30 minutes. Since comparable intravascular cortical pressures were sought, the hypotensive state was always induced after exposure of the cerebral cortex.

Pressure Data.—The first group of observations had to do with the relation between arm cuff pressure and intravascular radial artery pressure. This is noted in Table 1 and recorded further in Tables 2 and 3. Although the readings were made of necessity in opposite arms, no gross variation in preoperative cuff readings of systolic-diastolic pressure was observed between the upper extremities in these patients. With the exceptions of cases M. B. and E. B. 2, all arm cuff pressures were significantly higher than pressures recorded in the radial artery. Of more importance in the routine conduct of controlled hypotension was the repeated observation that arm cuff pressures might disappear at levels of 60 mm. Hg or less as recorded within the radial artery (Tables 1 and 2). Thus at the most critical period of induced hypotension, it seemed clear that arm cuff pressures became of little or no value. In this series of patients, only the use of radial intravascular pressure recordings gave a continuous and accurate index of the degree of induced hypotension.

‡ Ciba Pharmaceutical Products, Inc., supplied the Pendiomid.

§ Hoffman-LaRoche, Inc., supplied the Arfonad (camphorsulfonate trimethaphen).

TABLE 1.—*Mean Arterial Pressure Changes Before and After Chemically Induced Hypotension*

	Before		After	
Case	Cuff	Radial	Cuff	Radial
E. B.	153	120	94	69
E. F.	127	111	75	49
R. H.	120	110	79	36
E. P.	188	145	70	50
K. S.	100	72	71	48
E. D.	90	78	0	24
W. L.	90	70	0	10
J. P.	90	74	0	28
H. T.	107	80	0	26
M. B.	127	135	0	38
E. B. 2	94	103	0	31

TABLE 2.—*Mean Arterial Pressure Changes Before and After Chemically Induced Hypotension*

	Before			After		
Case	Cuff	Radial	Cortical	Cuff	Radial	Cortical
W. A.	102	94	94	82	70	52
M. B.	104	90	44	54	55	20
F. H.	113	99	70	81	99	64
K. O.	73	73	55	60	49	41
V. R.	86	80	50	60	38	26
M. S.	104	85	66	81	60	36
L. B.	97	87	20	51	37	4
C. Mc.	133	..	100	93	..	62

TABLE 3.—*Mean Arterial Pressure Changes Before and After Chemically Induced Hypotension*

	Before			After		
Case	Cuff	Radial	Cortical	Cuff	Radial	Cortical
A. R.	114	84	66	0	68	56
B. S.	91	90	80	0	68	40
D. Mc.	129	99	56	0	45	24
G. S.	103	86	79	0	37	..
H. K.	126	84	64	0	16	12
C. T.	145	93	45	0	21	20
M. W.	108	89	83	0	23	21

TABLE 4.—*Per Cent Fall (Average) of Mean Arterial Pressure with Chemically Induced Hypotension*

Compound	No. of Cases (Total)	Cuff, %	Radial, %	Cortical, %
Pendiomide	16	35.4	50.2	41.9
Hexamethonium	8	30.5	61.5	60.0
Camphorsulfonate trimethaphen	2	32.7	45.2	52.7
All compounds	26	34.6	52.9	47.6

When arm cuff, radial, and cerebrocortical readings were compared in the control group, the usual pressure gradient already observed in the carotid arterial tree was apparent, although variations consistent with cortical vessel size were noted. In nine cases, cortical artery pressure readings were found below a level of 50 mm. Hg. and it is to be assumed that the six cases in Table 1 with radial artery pressures below this level attained cortical pressures of similar magnitude. These cases, then, in the course of induced hypotension approached levels of cerebral intravascular pressure for varying periods of time that have been shown in previous work to be critical levels in terms of tissue necrosis. In all cases in which such degrees of hypotension were recognized, postural change, the injection of levarterenol (Levophed), or both measures were used to elevate intravascular pressure to a point above that of 50 mm. Hg. The average fall in mean arterial pressure with controlled hypotension with use of these three agents is found in Table 4.

SUMMARY

These data show the rather significant variations in pressure obtained by the arm cuff method and the systemic arterial pressure as recorded in the radial artery. It seems clear that the actual fall in systemic arterial pressure induced by ganglionic-blocking drugs may be more profound than that demonstrated by the arm cuff method and may approach a level incompatible with cortical function. When systemic arterial pressure reaches a critical level of 50 to 60 mm. of mercury, no arm cuff pressure can be heard. This observation emphasizes the inadequacy of arm cuff pressures under such circumstances. These studies also indicate the fact that for these purposes, the arterial pressure within the cranial cavity approximates that found within the radial artery.

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THE CASE FOR HYSTERECTOMY

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AN ANALYSIS of 1,075 private patients who had hysterectomies was made to determine why the operations were performed and what the results were. There were four deaths in this series, a mortality of 0.37%. Two were sudden, from pulmonary emboli, each occurring the 14th postoperative day, as the patients were ready for discharge from the hospital; the third was from acute pyonephrosis and myocardial infarction, occurring the 23d day, after a normal convalescence at home from vaginal hysterectomy, with death on the 28th day. The fourth patient had had resection of the sigmoid, resection of the terminal ileum, and removal of the uterus, both tubes and ovaries and most of the urinary bladder for carcinoma of the sigmoid invading the pelvic organs. Death occurred after 12 days from peritonitis which developed from a leak in the end-to-end sigmoid anastomosis. Total hysterectomy was performed in 979 cases (91.1%), subtotal hysterectomy in 96 cases (8.9%). In the last 500 abdominal hysterectomies, 99.4% (all but 3) were total hysterectomies. In many, the reasons for surgery were obvious, while in others there were varying factors requiring detailed history, personal knowledge of the patient, surgical judgment, and observation. An evaluation of the operation and delineation of the case that needs hysterectomy seem of great importance because of confusion and misunderstanding on the part of some of the medical profession and, unfortunately, much of the general public.

When the health of a woman, physically and emotionally, is compromised by an abnormal uterus to a serious degree (and the judgment of this degree of disability is squarely on the shoulders of the conscientious surgeon performing hysterectomy), excision has proved one of the most satisfactory procedures in all surgery.* The emotional confusion in consideration of the sexual organs, femininity, and procreation has prevented some from seeing or realizing the great importance of extending hysterectomy to those in dire need of it. Hysterectomy should never be performed for minor complaints and minor findings, but only when there are major diseases or when those complaints and findings add up to a major disability.

For a century, perhaps for many centuries, nervous complaints in women have been attributed to the menopause (at any age whatever, whether menstruating or not) or to certain minor or major physical abnormalities which may be present in the pelvis. It is only after accurate observation and examination have indicated precisely which symptoms are caused by the specific findings in the pelvis, that one can expect relief from the symptoms by correction of the pathological conditions present. Every surgeon must beware of attempting to correct symptoms that cannot

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* References 1 through 5.

possibly be caused by abnormality in the pelvic organs. When operations are mistakenly performed for anxiety states, nervous exhaustion, overwork, tension, or headaches, the patients are often not helped and further deterioration may follow.[6] One of the greatest pitfalls is the performance of surgery for severe or marked pain when there is no demonstrable pathology. After study and observation, one may decide properly that exploratory operation is necessary. Some patients may be cured by this procedure, even though no obvious explanation for the pain is discovered, but more are not cured or may even develop various other complaints.

This paper is an attempt to classify our patients with hysterectomy as accurately as possible. This includes a newer approach to our largest group; probably it is only a manner of stating considerations that gynecologic surgeons understand and use but do not put into words. Undoubtedly the indications have been much broadened

TABLE 1.—*Prime Reason for Hysterectomy in 1,075 Cases*

		Cases	
A.	Abdominal		875
1.	Myomas	263	
	(a) Large	128	
	(b) Painful	42	
	(c) Bleeding	93	
2.	Adenocarcinoma of endometrium	49	
3.	Salpingitis	75	
4.	Ovarian tumors	32	
5.	Endometriosis	100	
6.	Carcinoma cervix uteri	31	
7.	"Combined syndrome"	277	
8.	Menometrorrhagia	31	
9.	Retroversion	3	
10.	Pregnancy and complications	7	
11.	Postoperative adhesions	3	
12.	Cervicitis	1	
13.	Cervical stricture	1	
14.	Sarcoma of uterus	1	
15.	Carcinoma of sigmoid	1	
B.	Vaginal hysterectomy		200
16.	Third degree prolapse, cystocele, rectocele	23	
17.	First and second degree prolapse with relaxation and uterine disease	175	
18.	Uterine disease without relaxation	2	

from 30 years ago, when only very large tumors, extensive inflammatory disease, or obvious invasive cancers were considered suitable for surgery, probably because of the greater morbidity and mortality attending the hysterectomy then.

ABDOMINAL OPERATION

1. Myomas of Uterus (263 Cases).—(a) Large Size (128 cases): Hysterectomy for myomas has long been performed for three reasons: size, pain, and profuse bleeding.

One hundred and twenty-eight uteri were removed primarily because of a large tumor (Table 1). The uteri were larger than a three month's pregnancy or a large grapefruit. Ordinarily, the mere presence of such a tumor is sufficient reason for removal unless the patient is a poor risk, is psychologically unprepared, or prefers to have the tumor observed. Twenty-three had menorrhagia of such degree that this might have been an indication alone, but the size seemed so prominent the cases were listed in this category. One hundred and fourteen were followed (from 3

months to 13 years, the majority longer than 1 year) and are considered to have had good results. Two were not followed, and 12 had various complaints. These complaints included nervousness in all, heavy feeling, dizziness, pains in pelvis, backache, pains in one side, "husband trouble" (two), and cancerophobia. One had shock therapy before operation, with repetition several times since. This is a small percentage of complainers or persons feeling no better than before operation; this includes inadequate individuals with problems who could be helped by reassurance. Since the size of the tumor was usually obvious, functional results rarely were disappointing. There were multiple other lesions in many of these cases, fortunately also cared for incidental to removal of the large tumor. Three patients had unsuspected sarcomatous change in myomas, and one had unsuspected carcinoma in situ of the cervix.

(b) Pain (42 cases): Hysterectomy was performed primarily for myomas with pain, in 42 cases. In each instance, the myoma was large enough to cause pain from pressure against the lateral wall of the pelvis, from extension beneath the bladder or against other pelvic viscera. Twenty-nine patients were considered to have had good results, even by using stringent criteria. Thirteen subsequently complained of nervousness; many of the laity and some of the profession might consider these poor results. These patients were recognized to be of the anxiety type before the operation, but pressure pain was so marked that surgery seemed necessary. All but four were relieved of their pelvic pain; one became more depressed and committed suicide one year after operation. This latter patient had mild to moderate agitated depression before the operation, and it was doubtful the procedure affected the outcome. One highly nervous woman had unexplained pain for two years longer, which then disappeared. Two patients were highly nervous because of marital problems, present long before the operations. Another unmarried woman relieved of pain continued emotionally unstable. One complained of backache and nervousness, another of nervous exhaustion; another had always been very nervous for unexplained reasons, and the last had cancerophobia. All had anatomically good results. One early and unsuspected adenocarcinoma of the cervix was found.

(c) Bleeding (93 cases): Myoma, accompanied by profuse bleeding, was the indication for operation in 93 patients. Menorrhagia was the prime complaint, usually being reflected by some degree of secondary anemia. The myomas were of sufficient size to produce an obviously much enlarged uterus. There were numerous other pelvic lesions in this group, but while important, they were asymptomatic or were overshadowed by the presence of the tumor and profuseness of the bleeding. Three patients who showed unsuspected sarcomas in myomas were well two, three, and six years later, respectively. Seventy-six had good results and no complaints.

Of the 16 patients with complaints, 5 had nervousness with no clearly ascribed reason. This seemed more than the usual tension of everyday life. An additional patient had nervousness and pruritus vulvae; a seventh had backache and exhaustion; an eighth had cancerophobia; a ninth was under great pressure, with an ill husband and a son in Korea. Three nervous patients had unexplained pains, two in the left side and one in the vagina. A 13th was nervous over her temperamental surgeon-husband. A 14th had marital difficulties for years with her pseudodoctor husband. A 15th developed a manic psychosis in the postoperative period; she and her family had carefully withheld information of previous manic-depressive episodes

with repeated shock therapy. The 16th was a nervous, difficult, and spoiled woman. A 17th patient said she felt no better, simply did not bleed anymore. All had good anatomical results.

2. Adenocarcinoma of Uterus (49) Cases.—Forty-nine patients (4.6%) had panhysterectomy and bilateral salpingo-oophorectomy for adenocarcinoma of the uterus (Table 2). Of these 19 had preoperative intrauterine radium treatment (usually 5,000 mg.-hours). Diagnosis was made by examination of curettings. If the tumor was large or clinically long standing, radium was inserted into the uterus, and operation was performed six weeks later. If the uterus was not particularly enlarged, and the tumor apparently not long standing or extensive, immediate surgery, removing a generous portion of the vagina, was preferred. Shrinkage of an enlarged uterus after radium seemed helpful. Statistical studies have not proved conclusively the value of preoperative irradiation, in part because of the great difficulty in arranging strictly comparable series. Of 19 with radium before surgery, 1 had recurrence and died, another now has recurrence, 1 died of embolus on the 14th day, and 1 is lost to follow-up. Of the 28 who had surgery alone, 1 died of recurrence, 1 is lost to follow-up, and 1 was operated on only four months before this paper was written. Two patients had radical hysterectomy, which definitely is

TABLE 2.—*Adenocarcinoma of Uterus*

		Alive and Well, Yr.				
		1	2	3	4	5+
Radium and panhysterectomy	19	6	4	3	1	1
Panhysterectomy	28	8	5	7	0	5
Radical panhysterectomy	2	..	..	1	1	..
Total	49	14	9	11	2	6

preferable, but obesity, age, and concurrent medical disease usually made this impractical in the others. Many of these patients had nervous problems, menopausal symptoms, and severe anxieties of return of cancer. Most of them continued to worry, but some were surprisingly nonchalant.

3. Salpingitis (75 Cases).—In 75 cases (6.9%), the prime reason for hysterectomy was the presence of chronic salpingitis. This was not a large percentage of the total affected by inflammatory disease, as many operations were rendered unnecessary by medical therapy. But persistent symptoms and palpable masses were indications for surgery. Table 3 shows the frequency of multiple associated lesions in this group. The multiplicity of abnormalities provided additional reasons for hysterectomy. One patient had unsuspected sarcomatous change in a myoma. The average age of 37.5 years accounted for many of the abnormalities usually associated with late menstrual life. As a general rule, hysterectomy was the operation of choice when it was necessary to remove the Fallopian tubes, because the uterus is prone to undergo functional disturbances or become affected by neoplastic disease at this age period. Occasionally in very young women it may be psychologically advantageous not to remove the uterus after bilateral salpingectomy, though subsequent surgery may become necessary. In older women, hysterectomy very definitely is preferable, since incomplete operation often leads to further invalidism. In my 1,075 patients, a second operation (hysterectomy) was necessary in 20, all of whom had had their Fallopian tubes removed elsewhere.

Tuberculous salpingitis was present in five patients (6.6% of salpingitis cases), and two also had tuberculous endometritis.

Fifty-eight patients (including all with tuberculosis) were recorded as having a good result from the surgery. Seven patients two to six years later complained of nervousness but had no pain; they had always been nervous. One was in process of procuring a divorce; another had severe difficulties with her mother-in-law; another had recurrent depression and cancerophobia. Ten patients complained of intermittent low abdominal pain and nervousness; four of these were severe psychoneurotics; three had recurrent palpable tender masses, although the uterus, both tubes, and ovaries were removed. In two of the latter, the vaginas were thick with full estrogenic smears, indicating regeneration of ovarian tissue from fragments unknowingly left behind after removal of the inflammatory masses.

TABLE 3.—*Salpingitis (75 Cases)*

	Cases
Good result	58
Nervous complaints	7
Pelvic pain	10

Associated Lesions			
Cervicitis	42	Tbc. endometritis	2
Myoma	29	Tbc. salpingitis	5
Retroversion	16	Tubovarian cysts	14
Adenomyosis	7	Hematosalpinx	4
Subinvolution	6	Dermoid cyst, ovary	1
Cervical polyp	6	Endometriosis, ovary	6
Myometritis	1	Pseudomucinous cyst	3
Endometrial polyps	4	Endometrial hyperplasia	5
Descensus, 1st	2	Sarcoma	1
Metrorrhagia	7	Bartholinitis	3
Menorrhagia	7	Postmenopausal bleeding	1
Dysmenorrhea	2	Rectocele	10
Endometritis	4	Cystocele	5
		Subacute bacterial endocarditis	1

The adage "a surgeon will not make a reputation operating for salpingitis" was borne out in these 10, who continued to complain of postoperative pain.

4. Ovarian Tumors (32 Cases).—Thirty-two patients were operated upon primarily because of ovarian tumors. Seventeen had benign ovarian cysts; 3 had benign solid tumors, and 12 had carcinoma of the ovaries. Of the 17 with benign ovarian cysts, 6 were of the serous type, 5 were pseudomucinous, 1 was inflammatory, 3 were large endometrial cysts, 1 was a dermoid, and 1 was a ruptured corpus luteum cyst. The solid tumors included fibroma in two and bilateral arrhenoblastoma in one. Hysterectomy was performed in these 20 benign cases largely because of associated disease. This included cervicitis in six, cervical polyp in one, endometrial polyps in three, salpingitis in two, myomas in seven, adenomyosis in five, endometriosis in three, retroversion in one, and other ovary absent in two (Table 4).

There was unilateral involvement in 7 and bilateral involvement in 5 of the 12 cases of carcinoma of the ovary (1.1% of the total with hysterectomy). All but three patients were over 46 years of age; all but two had postoperative

x-ray therapy. Two died (both had had x-ray therapy); the others are alive from 1 to 14 years after surgery. As a rule, both ovaries and the entire uterus were removed when there was carcinoma in one or both ovaries.

5. Endometriosis (100 Cases).—One hundred patients had operation performed primarily because of endometriosis (Table 5). Hysterectomy was performed at the time the abdomen was opened, either because of extensive bilateral adnexal or extrauterine endometriosis, or because of concomitant uterine disease. Actually, many more in this series of 1,075 hysterectomies had some degree of associated endometriosis, but it was not a prime factor in precipitating operation. Conserva-

TABLE 4.—*Ovarian Tumors* *

			Years Observed				
			1	2	3	4	5+
Benign							
Cyst							
Serous	7						
Pseudomucinous	5						
Inflammatory	1						
Endometriosis (large)	3						
Dermoid (large)	1						
Ruptured lutein cyst	1						
Solid							
Fibroma	2						
Arrhenoblastoma	1						
Malignant							
Unilateral	7		..	1	1	1	2
Bilateral	5		3	..	1	..	1

* Two died.

TABLE 5.—*Endometriosis (100 Cases): Associated Lesions*

	Cases		Cases
Myoma	53	Endometrial cyst, ovary	48
Cervicitis	55	Serous cystadenoma, ovary	1
Retroversion	21	Fibroma, ovary	2
Adenomyosis	23	Pseudomucinous cystadenoma, ovary	1
Endometriosis, cervix	5	Hydrosalpinx	4
Endometrial polyp	10	Endometriosis, vagina	1
Cervical polyp	3	Ventral hernia	1
Adenomyoma, rectovaginal septum	6	Relaxed vaginal outlet	18
Subinvolution	7	Rectocele	10
		Cystocele	3

tive operations with intention to retain or improve fertility were performed in 40% of all cases of endometriosis in which I have operated.[7] Extensive surgery was necessary here because of widespread and severe endometriosis. Three-fourths of the patients were above the age of 35 years.

Follow-up studies reveal that 80 patients had a good result, with no significant complaints (64, from 1 to 12 years). Ten patients had no pain but much nervousness. One was paranoid concerning her husband's employer (this began years earlier); one had an irresponsible husband; two had cancerophobia; one feared hirsutism and blindness; one was an alcoholic widow; one was disappointed at being sterile, and three were nervous for no known reason (each had been just as nervous before the operation). Ten patients complained of pain and nervousness. Four of these had severe marital difficulties. Three were considered extremely

neurotic. One was reoperated upon elsewhere for adhesions. One developed a guilt complex over hysterectomy and had shock therapy, with good result. One had complaints which could not be explained.

If essentially all of the endometrial implants were removed, estrogens were given in small doses. Long after operation in cases in which there was extensive endometriosis, small dosages of estrogens were given cautiously. If a large amount of residual endometriosis was obvious, and especially if it had been found deep in the bowel wall, estrogens were not given. Testosterone was substituted if necessary, though this treatment was not desirable over long periods because of hirsutism. Most patients were given small doses of phenobarbital as indicated for menopausal symptoms.

TABLE 6.—*Carcinoma of Cervix Uteri*

	Total		No. Cases Living and Well After Yr.				
			1	2	3	4	5+
In situ (after biopsies)							
Panhysterectomy	3		1	..	1	1	..
Early carcinoma (invasive)							
Panhysterectomy	2		..	1	..	1	..
Radical panhysterectomy	3		..	2	..	1	..
Carcinoma, stage I and II							
Panhysterectomy followed by x-ray	4		..	..	..	..	2
Panhysterectomy after radium (stage I)	1		..	..	..	..	1
Panhysterectomy after x-ray and radium (stage II)	1		1	..	..	..	..
Radical hysterectomy with nodes	4		1	2	..	..	1
Radical hysterectomy with nodes; preop. x-ray	11	1 died 1 yr. 1 recurr. 6 mo.	2	2	..	..	5
Radical hysterectomy with nodes; preop. radium	1		..	..	1	..	..
Carcinoma stage III and IV							
Excision uterus, vagina, bladder (stage IV)	1	died 6 mo.	..	..	..	..	..
Excision uterus, vagina, bladder, rectum (stage IV)	1	died 6 mo.	..	..	..	..	..
Subtotal hysterectomy after x-ray (stage III)*	1	died 1 yr.	..	..	..	..	..
Total	28	Carcinoma of cervix (2 adenocarcinoma)					
Total	3	Carcinoma in situ					

* Operation planned for radical excision; corpus uteri inadvertently amputated by palpation; inoperable.

6. Carcinoma of Cervix Uteri (31 Cases).—The introduction of radium therapy for carcinoma of the cervix uteri by Kelly and Burnham in 1912[8] was a great advance, dramatic results occurring in a fair percentage of cases. Today it is still a most important therapeutic agent, curing 60 to 70% of clinical Stage I carcinomas. But there remain 30 to 40% of cases, apparently limited to the cervix, not cured by irradiation therapy. It is doubtful that cytologic examination of smears will show which are sensitive, which insensitive. Examination of serial biopsy specimens during the pre-radium roentgen irradiation may reveal the unresponsive tumors; this is being studied by Glucksmann.[9] Radical hysterectomy, with careful lymph node dissection, has been reintroduced with modern meticulous technique by Meigs.[10] Because of failures with patients who should have been cured, I determined to perform radical hysterectomy and lymph node dissection as a routine for clinical Stage I cases of cervical cancer after a full course of deep x-ray therapy to the parametrial and node-bearing areas. Preoperative treatment with radium

was avoided because of possible effects on fistula formation. Surgery was performed in 28 patients (2.6%) with invasive carcinoma (Table 6). One ureteral fistula healed spontaneously in three months; no others occurred. During this same period, a somewhat larger group was treated with irradiation therapy alone because of advanced stage, obesity, age, medical diseases, or refusal of operation. Six patients were followed one year or less, the remainder for two to six years. Three with extensive carcinoma died in one year. The remainder showed no recurrence. In addition, three patients with proved preoperative diagnosis of carcinoma in situ, had conservative hysterectomy.

7. "Combined Syndrome" (277 Cases).—The "combined syndrome" [11] may be described as a combination of multiple organic abnormalities in the pelvis associated with multiple, positive, and distressing related symptoms which summate to a major disability. The findings alone usually do not necessitate hysterectomy unless there are strictly severe symptoms. Of 875 abdominal hysterectomies, 277 have been catalogued in this group.

Vaginal outlet relaxation, cystocele or rectocele, at times enterocele, descensus of the uterus of first or second degree, retroversion of the uterus, or "general pelvic relaxation" with the associated enlarged pelvic veins, "pelvic congestion," or "congestion fibrosis syndrome," may be placed together, and are commonly related to one basic part of the findings of this syndrome. In the abdominal cases, a relaxed vaginal outlet occurred in 165, rectocele in 140, a third degree tear in 1, and a rectovaginal fistula in 1, and all required repair. A cystocele was separately repaired in 54 and a relaxed vesical sphincter in 4, and a suburethral diverticulum was excised in 2. First degree descensus occurred in 85 and second degree to the outlet in 14. Retroversion was present in 98, subinvolution in 73, fibrosis uteri in 11, femoral hernia in 1, ventral hernia in 3, and umbilical hernia in 4.

Of the abdominal group of 277 with "combined syndrome," myomas were present in 126. The reason these myomas are not placed with the large group of myomas as an indication per se is that these tumors did not have any of the three strict indications for hysterectomy on the basis solely of the myoma, namely, large size, profuse bleeding related to the tumor, or pain due to actual pressure from the tumor. On the other hand, the multiple smaller fibroid tumors here added to the dysfunction, weight, pressure symptoms, and prolapse of the uterus, and were definite additive factors in these particular cases.

Cervicitis of moderate to severe degree was present in 230. Of itself, cervicitis ordinarily may be well treated by cauterization, but some patients with marked hypertrophy, deep lacerations, and severe ulcerations are better treated by hysterectomy. Amputation of the cervix is rarely a satisfactory operation. Cervicitis was not a major reason for hysterectomy in the series, but it was an additional and, at times, important factor. Unsuspected malignant lesions occurred in six cases: carcinomas in situ of the cervix in two, early carcinoma of the cervix in one, malignant endometrial polyp in one, and early carcinoma of the ovary in two. Endometriosis of the cervix occurred in 2 and adenomyosis of the uterus in 41. Cervical polyps were present in 20 (not an important factor), endometrial hyperplasia in 39, and endometrial polyps in 32.

Salpingitis was recorded by the pathologist in 41, and pelvic endometriosis occurred in 84. These latter two conditions might have been placed in their separate groups as indications by themselves for hysterectomy, but in these particular

cases, while the pathology was definite, the symptoms and findings of the particular disease were not alone sufficient to necessitate hysterectomy; only when combined with the other multiple findings did a real indication exist.

Fibroma of the ovary occurred in 9 patients, dermoid cyst in 4, pseudomucinous cystadenoma in 2, serous cystadenoma in 2, and parovarian cyst in 17.

There were symptomatic abdominal adhesions in 15, from previous operations performed elsewhere, and both tubes had been removed in 9. One patient, aged 45, had severe ovulation pain. Menorrhagia was present in 81 (persistent in 1 case despite curettage, suspension, and medical therapy), metrorrhagia in 29, postmenopausal bleeding in 6, severe dysmenorrhea in 27, and unexplained abdominal pain in 1. Consultants advised sterilization of one patient for congenital heart disease, one for epilepsy, and two others for psychiatric reasons. In each there were other reasons for hysterectomy. In another with "combined syndrome," the uterus was ruptured and left broad ligament mistakenly injured by a curette, precipitating hysterectomy.

Two hundred fifty patients are considered to have had a good result, and 168 have been followed from 1 to 14 years.

A more detailed review of 27 patients with not the best results seems justified. One died of pulmonary embolus. The main complaint of the others has been nervousness in 26, although most of them had been quite nervous before operation. One was anxious over marriage of a daughter below her social standing; two were involved in constant family upsets; one worried much over her children; one was preoccupied over finances; three became divorced; another had a paranoid husband; one complained of dyspareunia. Six complained of low abdominal pain, two of exhaustion. One was not certain whether she was improved after a year, but her husband said she was, with relief of discharge from the severe cervicitis and menorrhagia from the enlarged uterus. In a divorce proceeding one husband wrote his wife that he would "never go to the expense of having another woman sterilized." One patient was a 69-year-old woman whose pain, after exhaustive study, was thought related to myomas of the uterus and cervical stricture; the pains remained. Another had been upset for three years because her ovaries were removed at 49 with hysterectomy. One husband wrote after two years that I left his wife in a "hell of a shape"; the result seemed good when the patient was last seen, three months after operation. One woman continued nervous, with intermittent severe pain; no explanation for the pain was found at surgery. Another, with divorce projected since long before the operation, had nausea, vomiting, and hot flashes six months later, considered functional. Another was very nervous, had severe family difficulties and symptoms of hysteria but said her pains were better.

One patient said she was sorry she had had a hysterectomy, although she felt better, as her husband was less interested sexually because the "sporting chance" of pregnancy was removed. One patient was a "worst" psychological result. Hysterectomy was performed, after prolonged observation, in this patient who, at 31, had had two children, previous appendectomy, and previous suspension and removal of the right ovary elsewhere. She had recurrent retroversion, second degree descensus, endometriosis, dyspareunia, menorrhagia, and pelvic pain. Three years later, she stated that she had no pain or discomfort, had gained normal weight, but was sorry she had the hysterectomy because it made her moody and caused headaches and

nervousness. She said it was "not right to take menstruation from a young woman," and that she would have liked to have more babies. These factors had been discussed with her in detail before surgery.

Even these complaining patients were really improved, in my opinion. Nervous people may have organic difficulties, but nervousness cannot be excised. The patient should understand this, but evidently thorough preoperative explanations may not be remembered. It is in this group of "combined syndrome" of symptoms and multiple gynecologic abnormalities that misjudgment is likely to occur. It is here that the most accurate diagnostic skill is necessary. Poor psychological results after

TABLE 7.—*"Combined Syndrome" (277 Cases)*

Age Group	Cases	Age Group	Cases	Age Group	Cases
20 to 24	4	35 to 39	71	50 to 54	20
25 to 29	8	40 to 44	72	55 to 59	3
30 to 34	40	45 to 49	57	60 to 64	1
				65 to 69	1

Associated Lesions

Relaxed vaginal outlet	165	Myometritis	1
Rectocele	140	Early unsuspected ca cervix	1
Third degree tear	1	Salpingitis	41
Rectovaginal fistula	1	Pelvic endometriosis	84
Cystocele	54	Endometriosis tube	2
Relaxed vesical sphincter	4	Fibroma ovary	9
Suburethra diverticulum	2	Dermoid cyst	4
Descensus, 1st degree	85	Pseudomucinous cystadenoma	2
Descensus, 2d degree	14	Serous cystadenoma	2
Retroversion	98	Carcinoma ovary, early	2
Subinvolution	73	Parovarian cyst	17
Fibrosis uteri	11	Tubo-ovarian adhesions	3
Femoral hernia	1	Endometrial cysts, ovary	11
Ventral hernia	3	Adhesions, postoperative	15
Umbilical hernia	4	Both tubes absent	9
Urethrocele	1	Severe ovulation pain	1
Acute anteflexion uterus	2	Menorrhagia	81
Myoma	126	Metrorrhagia	29
Cervicitis	230	Postmenopausal bleeding	6
Carcinoma in situ	2	Dysmenorrhea	27
Endometriosis cervix	2	Unexplained abd. pain	1
Adenomyosis	41	Congenital heart disease	1
Cervical polyps	20	Epilepsy	1
Endometrial hyperplasia	30	Uterus ruptured by curette, hematoma in left broad ligament	1
Endometrial polyps (1 malignant)	32		

surgery for malignant disease or very large tumors are largely ignored because the operation seemed mandatory, but poor results in those occur just the same. In these, too, psychological explanations are most important for patients to be happy.

8. Menometrorrhagia (31 Cases).—Thirty-one patients had hysterectomy primarily because of menorrhagia or metrorrhagia. Seven were above the age of 50, and four others above the age of 45. These were all severe "menopausal bleeders," six had had previous curettage (twice in one case) but had recurrent bleeding. In one, with postmenopausal bleeding at 63, the uterus had been ruptured with a dilator; hysterectomy was performed because of the possibility of malignant disease. In these cases various lesions such as endometrial hyperplasia, small myomas, and adenomyosis were found after operation. Nine of these 11 patients were much improved; 1 was nervous after her husband committed suicide; another had anxiety neurosis.

Twelve patients were between 36 and 45 years of age. Five had had previous curettage, without improvement: One had had radium therapy and recurrent metrorrhagia; one had endometrial changes suggestive of early carcinoma; two had both tubes absent, and one had had previous ventral fixation. One patient had a bicornuate uterus. Various minor abnormalities were found, and one patient had a large placental polyp. Ten patients had good results; two complained of nervousness but had no pelvic complaints.

Six patients were between 29 and 35. Four had previous curettage, a fifth had had both tubes removed, and the sixth had developed such extreme anxiety over severe menorrhagia that hysterectomy was necessary. Two were nervous (one has an alcoholic husband; the other, family trouble); the remainder have no complaints.

Two patients are in a special category. One was 22 years old, with prolonged severe bleeding, enlarged uterus, with a massive, firm nodular endometrial polyp extending half through the muscular wall (to be the subject of a separate report). The other had puberty bleeding at 15; multiple transfusions, curettage and multiple hormones had been used in treatment, with recurrent severe bleeding and anemia. This occurred in 1946. I believe the bleeding might have been controlled by progesterone withdrawal bleeding, but at that time our understanding of the best use of progesterone was not clear.

9. Retroversion, Uterus (Three Cases).—Symptoms from retroversion were rarely a cause for hysterectomy, and in these few cases there were complications. One patient who had had both tubes and ovaries previously removed was observed one year before this operation; one had had both tubes removed and the uterus was adherent; the third had subinvolution, cervicitis, and first degree descensus, and hysterectomy seemed better at 39 than suspension. These patients were improved. Many others whose cases were included under endometriosis and "combined syndrome" had retroversion of the uterus, but in only these three was the prime factor for operation related strictly to the retroversion.

10. Pregnancy and Its Complications (Seven Cases).—This is a miscellaneous group, related only in so far as all these patients were pregnant. One patient had early rupture of tubal pregnancy and a tubo-ovarian inflammatory cyst on the opposite side; one had unruptured cornual pregnancy; one had an old tubal pregnancy and the opposite tube absent. Two had termination of pregnancy by hysterectomy because of tuberculosis and psychiatric disease, at the request of two specialists in each field. One had recurrent hydatid mole after curettage, increasing hormone titers, and enlarging huge lutein cysts. The last had an invasive hydatid mole (chorioadenoma destruens), recurrent after hysterotomy and two subsequent curettages. Five patients had good results; the other two had no discomfort but were nervous, with family difficulties.

11. Postoperative Adhesions (Three Cases).—Because of previous pelvic operations involving the uterus, with subsequent adhesions, three patients had hysterectomy. One had had ventral fixation; another had had one tube and ovary removed, and the uterus became adherent in the opposite angle of the pelvis; the last had had both tubes removed. Two were cured; the third had many complaints not related to the operation.

12. Cervicitis (One Case).—Because of severe cervicitis, studied by biopsies, hysterectomy was performed in one case; the patient had no complaints subsequently. Cervicitis was present in numerous other patients, as in patients with the "combined syndrome," but here it was the prime indication.

13. Cervical Stricture (One Case).—One patient, aged 41, had hysterectomy for severe dysmenorrhea and cervical stricture not responding to dilation. Conization had been performed previously. Five years after the operation, the patient continued highly pleased with the result.

14. Sarcoma of Uterus (One Case).—The preoperative impression of sarcoma of the uterus was confirmed in one postmenopausal patient who died a year later of pulmonary metastases. Seven other patients who had unsuspected sarcomatous change in myomas were alive and well after 1 to 10 years. These latter patients whose condition was unsuspected were included in the myoma and salpingitis groups because those conditions were the indications for surgery.

TABLE 8.—*Vaginal Hysterectomy (200 Cases)*

Condition	Cases, No.
Third degree prolapse, cystocele, rectocele	23
"Combined syndrome," 1st and 2d degree prolapse, relaxation	175
Uterine pathology, without relaxation	2

Associated Lesions

Cervicitis	181	Endometrial polyp	19
Myomas	79	Ovarian cyst	3
Subinvolution	34	Enterocele	5
Adenomyosis	32	Carcinoma, cervix	1
Endometrial hyperplasia	35	Carcinoma in situ	1
Retroversion	21	Endometrial carcinoma	1
Menorrhagia	21	Sarcoma	1
Metrorrhagia	8	Third degree tear	1
Cervical polyp	20		

15. Carcinoma of Sigmoid (One Case).—One patient had a preoperative diagnosis of carcinoma of the ovary. Exploration showed a large carcinoma of the sigmoid invading a loop of terminal ileum, the left tube and ovary, uterus, and bladder. The whole involved mass was somewhat moveable. No other metastases were noted. The sigmoid and ileum were resected, and the corpus uteri, both tubes and ovaries and two-thirds of the bladder were removed. The patient died 12 days later of peritonitis, the sigmoid anastomosis having separated.

VAGINAL HYSTERECTOMY (200 CASES)

Removal of the uterus by the vaginal route was performed 200 times in this group, 18.6% of total cases (Table 1), but much more commonly in the past three years. The percentage per year is nearly 30% recently. The indications for vaginal hysterectomy have been divided into three groups (Table 8). The first was for third degree prolapse with cystocele and rectocele and included 23 cases. There is almost universal agreement at the present time on this procedure. The Manchester-Fothergill operation of amputating the cervix and performing cystocele and rectocele repair, the Watkins interposition operation, and the LeFort vaginal obliteration operation may be preferred occasionally, but, as a rule, vaginal hysterectomy with

proper anterior and posterior colporrhaphy for third degree prolapse is superior. The second, and larger, group included first and second degree prolapse, with vaginal relaxation and multiple minor diseases of the uterus associated with positive symptoms (175 cases). In this category are included particularly the "combined syndrome," described in more detail earlier. Removal of uteri with second degree prolapse did facilitate the repair, but, as a rule, the uterus was removed purposely for disease. It is of importance to note that 4 of these 200 abnormal uteri had unsuspected malignant disease. The associated lesions are enumerated in Table 8. The third, and smallest, group was made up of cases with multiple uterine diseases without cystocele and rectocele and outlet relaxation (two cases). Undoubtedly this number will be increased in future years.

There were more postoperative complications in the group in which vaginal hysterectomy was done, particularly urinary difficulties. The commonest was delayed voiding, but if the retention catheter was reinserted without delay after attempts at voiding each few days the anxiety attendant on this problem was controlled. Six patients had recurrent enteroceles, 2 recurrent cystoceles, 22 slightly shortened vaginas, 8 slight dyspareunia, and 7 partial or stress incontinence. The vast majority of these patients were highly pleased, felt much improved, and were helped by the psychological factor of a scar that is invisible.

COMMENT

This detailed analysis is made to show what indications for hysterectomy were used in this private practice. There will be disagreements. Some will go to extremes in order to avoid performing hysterectomy. On the contrary, this study indicates the desirability and advantages of definitive surgery when strictly indicated. These indications are more numerous than those accepted 30 years ago in the ultraconservative school. They include only these features: positive symptoms and positive findings in a patient who understands what the procedure will do and who has been partially or wholly incapacitated, a patient who has not been unduly urged, who has thought the matter over carefully, and who wants the operation. This latter viewpoint has been emphasized by Burch.[3]

There are many pitfalls in this operation. The risks are very slight but should not be minimized to the patient. The despairing hope of an unhappy woman that hysterectomy might cure her nervousness must be constantly searched for and clarified. Rarely does hysterectomy cure nervousness, unless it is caused by pain, fear of fatal hemorrhage, knowledge of a lesion suggestive of a malignancy, or, occasionally, extreme fear of pregnancy.

The concern that performance of hysterectomy for metrorrhagia in late menstrual life will lead to too many operations does not change my strong belief that if such bleeding does not respond to curettage, thyroid therapy, and psychosomatic advice, hysterectomy usually is preferable to radium or roentgen therapy. This attitude has been stressed recently by Willson and Daly.[12]

A serious objection to the ultraconservative attitude is the risk of overlooking a malignant process. Not only must all patients with erosions of the cervix have biopsy (except in the very young) and all with irregular bleeding have curettage (except puberty bleeders), but great care must be exercised in differentiating pelvic tumors. A benign myoma must not be confused with an ovarian carcinoma. Unfortunately, at times only exploration can give the proper information. I reassured

a postmenopausal woman that she had a simple, harmless myoma; six months later laparotomy showed carcinomatosis. There was no myoma, and the tumor was an ovarian carcinoma. Such an error may occur again, but this one left a deep and painful impression.

In this series of 1,075 hysterectomies, there were 94 operations definitely planned with a preoperative diagnosis of malignant growth. This included malignant lesions of the endometrium, cervix and ovary, and represented 8.7% of the total operations. In addition, there were 19 unsuspected malignant growths found by the pathologist in the microscopic studies of the tissue submitted. These included eight sarcomas in myomas, four carcinomas in situ of the cervix, two invasive squamous cell carcinomas of the cervix, one invasive adenocarcinoma of the cervix, one adenocarcinoma of the endometrium, one adenocarcinoma in an endometrial polyp, and two early carcinomas of the ovary. This totally unsuspected occurrence of malignant processes in the excised tissue was 1.8%. One hundred and thirteen patients in the series had malignant growths (10.5%).

The number of patients who were nervous after their hysterectomies is stated clearly, but most of these women were nervous before the operation. Unfortunately, many hoped they would never be nervous again. It was so easy for the patient to forget the preoperative explanations and have such high hopes for cure of family troubles that they concealed their preoperative mental status. In those same cases, the gynecologic complaints were relieved as a rule; these were the complaints I expected to cure, but the patient tended to forget. The functional element in the patient as a whole is a factor in every branch of medicine and surgery; certainly it is prominent in pelvic surgery.

Some of our patients did not have good results. I am convinced it was a mistake to operate on four patients. One had symptoms that could not be explained by the adenomyoma in the rectovaginal septum. Two had severe pain, and were believed to have tumors. Exploration showed no tumors; hysterectomies were performed because the patients were at the menopause. One was much improved, the other worse. The fourth had hysterectomy at 40 years for left-sided pain, with only the finding of a myoma 2 cm. in diameter in the posterior wall. Some pain persisted, but the patient was pleased with the result. In each instance, I was misled by certain symptoms and apparent findings. In two or three, reexamination over a period might have made clear the tumor was not as large as originally thought and could not be responsible for the symptoms. It is important to reexamine complicated and difficult cases, especially when the symptoms are not clearly explained. The gynecologist must be keenly alert. The good results in 95 to 99% of carefully chosen cases make hysterectomy an exceedingly gratifying operation to both the patient and the surgeon.

SUMMARY AND CONCLUSIONS

Hysterectomy was performed on 1,075 private patients. These cases are analyzed and categorized according to the type of lesion and chief complaints. Criteria for operation are stated. Abdominal hysterectomy was performed in 875 (779 were total hysterectomies) and vaginal hysterectomy in 200 cases.

These cases may be divided into two groups, those in which hysterectomy was imperative and those in which hysterectomy may have been delayed for study or convenience: 1. The group in which hysterectomy was imperative included those

with large tumors, painful myomas from pressure, hemorrhaging myomas with anemia, malignant disease of the uterus, ovarian tumors, malignant or possibly malignant, marked endometriosis, and marked pelvic inflammatory disease. This group included those with severe diseases with very obvious permanent pelvic masses and commonly required surgery regardless of symptoms. These totaled 559 patients (52%).

2. The group in which hysterectomy may be delayed included mainly the cases with "combined syndrome," with multiple positive findings and symptoms which added up to a major disability. There were 277 of the cases in which the abdominal route was used and a majority of the 200 vaginal hysterectomies which fitted into the "combined syndrome." Including other miscellaneous cases, a total of 516 (48%) had hysterectomy which may have been delayed for convenience or study of a domestic state but which was necessary just the same for the best health of the patient. In this group, operation was partly elective and could be postponed for a limited period.

While 94 patients in this series had a preoperative diagnosis of malignant growth which was the indication for surgery, unsuspected malignant processes were found by the pathologist in an additional 19 patients. These lesions included eight sarcomatous changes in myomas, four carcinomas in situ of the cervix, two squamous cell carcinomas of the cervix, one adenocarcinoma of the cervix, one adenocarcinoma of the endometrium, one adenocarcinoma in an endometrial polyp, and two unsuspected carcinomas of the ovary. Of all patients operated upon, a total of 10.5% had a malignant growth.

Nervous complaints after the operation were common in all categories of patients, whether the patients had malignant growths, large tumors, or less obvious diseases. One expects the patient with a malignant condition to be nervous, but analysis here showed 14% of the "benign" group had functional nervous complaints. Study indicated that the complaints were not related to the operation (or menopause) in most instances. In 4.8% of the benign abdominal group, some degree of postoperative abdominal pain occurred. In retrospect, four patients (0.37%) are considered to have had unjustified hysterectomy.

It is for the group with "combined syndrome," multiple pelvic lesions with symptoms adding up to a major disability, that the most accurate clinical judgment must be exercised. Finally, decision should not be made until the patient has been interviewed several times, until all domestic factors have been taken into consideration, and until the patient understands clearly the reasons for the hysterectomy and the results to be expected. Patients with only functional nervous complaints are not suitable candidates for hysterectomy.

Hysterectomy is one of the most satisfactory of all surgical operations and offers great relief in properly selected cases.

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DIFFICULTIES OF DIAGNOSIS OF SOME LESIONS OF COLON

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LESIONS of the colon have always offered difficulties in diagnosis and treatment. Until the evolution of the electric light and the x-ray, diagnosis was seldom made except by palpation and by inference from the presence of intestinal obstruction. Surgical treatment was complicated by many factors. The contents of the bowel contained many pathogenic organisms that gave rise to peritonitis; interference with function by the lesions resulted in malnutrition and anemia, and intestinal obstruction caused alterations in body chemistry and physiology that were frequently fatal. The historical development of the operative treatment is interesting, and a knowledge of it is helpful to the present-day surgeon in his efforts to further improve upon it. The names of many surgeons have been associated with the increase in our knowledge of and the advances in our treatment of lesions of the colon. To mention a few, Bloch, Mikulicz, and Paul, pioneers in the field, made ingenious suggestions on how to remove a lesion by exteriorizing it so that the dangers of peritonitis would be minimized. One of the last and most effective of these exclusion operations was developed by Dr. Fred W. Rankin. His contributions to the subject go far beyond this mechanical contribution. The research that he stimulated and the work that he and his associates carried out have added importantly to our knowledge of the behavior of these lesions and to their diagnosis and therapy. As he has pointed out, diagnosis is usually not difficult when the time-tested methods are used early. On the other hand, many lesions of the colon are still difficult of diagnosis. These odd lesions of the colon may not fall into routine categories and may confuse those with much experience. In paying tribute to one of the pioneers in the study of cancer of the colon, we hope that surgeons might find interest in a short clinical presentation of some of the difficulties and oddities of diagnosis that trouble those who are called upon to treat lesions of the colon. We acknowledge and give credit to Dr. Rankin for his many basic contributions to what we know of the lesions of the colon and their treatment.

In the evaluation of a patient with a lesion of the large bowel, the surgeon is guided in determining his plan of therapy by a knowledge of whether the lesion is of a specific or nonspecific inflammatory nature or neoplastic, and if neoplastic whether benign, potentially malignant, or malignant. Many patients who present themselves with disease of the colon can be placed in one of these groups on the basis of history and physical examination alone. Sigmoidoscopic visualization of the rectum and sigmoid colon, and, when indicated, biopsy of the lesion, classify

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Figure 1 has been omitted because it was included in the article through error.

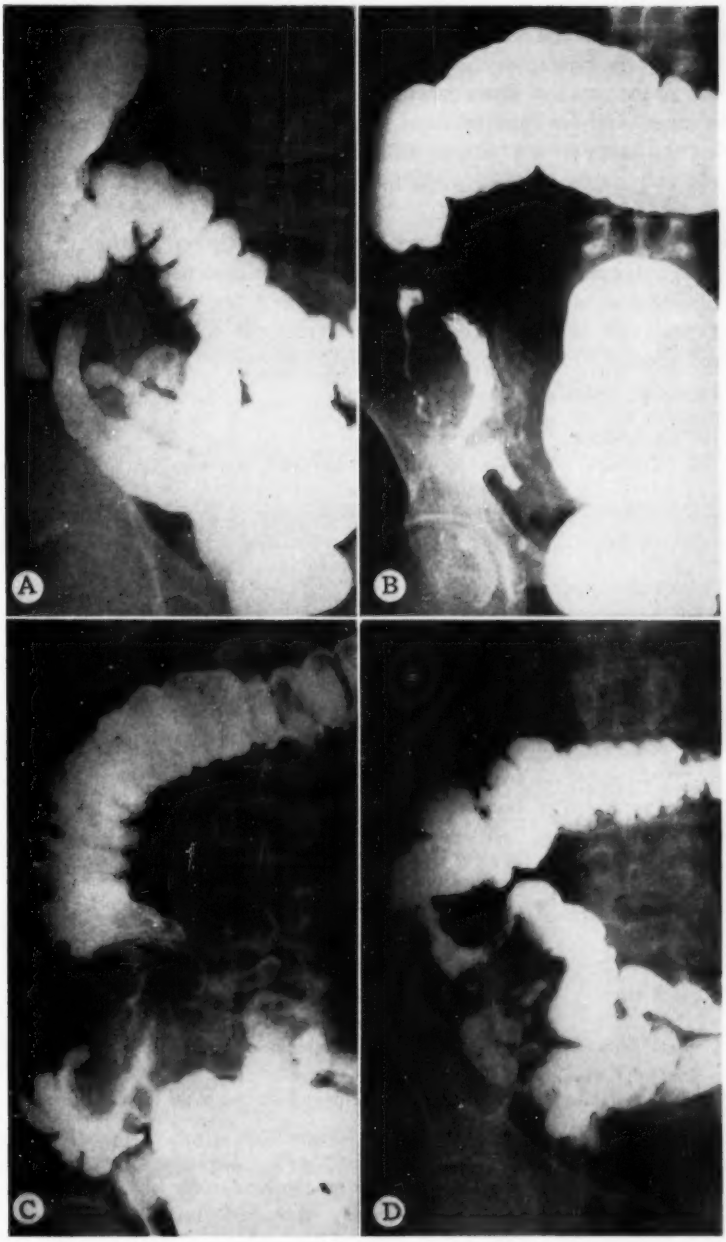

Fig. 2.—Roentgenograms showing (*A*) regional ileitis, (*B*) ileocecal tuberculosis, (*C*) carcinoma of cecum, (*D*) carcinoma of cecum.

most of the remainder of such cases. The diagnosis in other patients is not clear until x-ray study of the colon and stool examination have been accomplished. After complete clinical, laboratory, and x-ray investigation, there still remain a small minority of patients for whom a definite diagnosis of the nature of the lesion cannot be made, and for some of these it is even impossible to state with certainty whether the lesion is neoplastic or inflammatory. In this group the final diagnosis is made only at the time of operation or after microscopic examination of the specimen has been carried out.

These so-called problem cases are always of great interest to all concerned in their study. Occasionally there is a difference of opinion between the surgeon and the radiologist as to the true nature of the lesion. A few such cases encountered in recent years are herewith presented and contrasted with typical lesions of the involved areas.

Lesions of the Cecum.—

Case 1.—R. P.	26 year man
Clinical:	Two-year history of increasing diarrhea, right lower quadrant pain, weakess, and anemia
X-ray:	Extensive inflammatory disease of the ileocecal area (Fig. 2*A*)
Operation:	Right colectomy and resection of terminal ileum with ileotransverse colostomy
Pathological examination:	Regional ileitis or Crohn's disease
Case 2.—G. R.	28 year woman
Clinical:	Pulmonary tuberculosis for 12 years, with positive sputum. Three-year history of right lower quadrant pain and nausea. A 5 × 10 cm. tender mass palpable in the right lower abdomen
X-ray:	Characteristic example of advanced enterocolitis involving the terminal ileum and cecum (Fig. 2*B*)
Operation:	Ileosigmoidostomy for tuberculosis of the omentum and ileocecal region; biopsy of omentum
Pathological examination:	Omentum with miliary epitheloid tubercles
Case 3.—E. S.	34 year man
Clinical:	Recurring pain in right lower abdomen for four months; diagosed as acute appendicitis
X-ray:	Extensive neoplasm involving lower one-third of ascending colon but sparing the cecal tip (Fig. 2*C*)
Operation:	Right colectomy and ileotransverse colostomy
Pathological examination:	Mucin-forming papilliferous carcinoma of the cecum
Case 4.—E. S.	49 year woman
Clinical:	One and one-half year history of anemia, weakness, and right lower quadrant discomfort, progressively worse
X-ray:	Extensive abnormality of terminal ileum and proximal cecum; thought to be ileitis or tuberculosis (Fig. 2*D*)
Operation:	Right colectomy and resection of terminal ileum with ileotransverse colostomy
Pathological examination:	Adenocarcinoma of cecum

Inflammatory lesions of the ileocecal area, whether nonspecific, as in Figure 2*A* (Crohn's disease), or of specific etiology, as in Figure 2*B* (tuberculosis), usually involve the entire cecum, including the cecal tip, with extension to the terminal portion of the ileum. Carcinomas in the cecal area usually are polypoid and tend to spare the cecal tip and only rarely extend into the terminal ileum (Fig. 2*C*). However, in far-advanced cases, direct extension into the terminal ileum with involvement of the cecal tip may occur (Fig. 2*D*).

Lesions of Transverse Colon.—

Case 5.—R. S.	69 year woman
Clinical:	Two-month history of progressive upper abdominal pain and anorexia; no melena or weight loss; mass palpable in left upper quadrant
X-ray:	Intrinsic neoplasm involving midportion of transverse colon with the characteristic overhanging edges (Fig. 3*A*)
Operation:	Transverse colectomy
Pathological examination:	Poorly differentiated adenocarcinoma of transverse colon

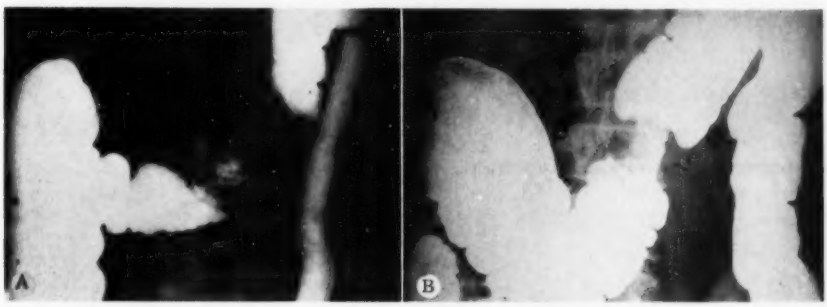

Fig. 3.—Roentgenograms showing (*A*) carcinoma of transverse colon and (*B*) amebic ulcer of transverse colon.

Case 6—J. D.	54 year man
Clinical:	Obstipation and difficulty in urination of one week's duration
X-ray:	Annular constricting lesion of the midtransverse colon thought to be malignant (Fig. 3*B*)
Operation:	Transverse colectomy
Pathological examination:	Chronic ulcer of transverse colon; repeated stool examinations finally revealed endamoeba histolytica

Neoplastic lesions of the transverse colon typically are annular in character, short in extent with overhanging edges, as in Figure 3*A*. It is interesting that this case of amebic colitis, Figure 3*B*, which was atypical in its distribution, sparing the ileocecal area, simulated a carcinomatous lesion roentgenographically.

Lesions of Sigmoid Colon.—

Case 7.—L. A.	43 year woman
Clinical:	Pelvic mass and history of old pelvic inflammatory disease
X-ray:	Definite displacement of the sigmoid colon to the right with narrowing suggestive of extensive pelvic disease (Fig. 4*A*)

Operation:	Total hysterectomy, bilateral salpingo-oophorectomy and excision of mass adherent to rectum and sigmoid and arising from uterus and left Fallopian tube
Pathological examination:	Endometrisis and old inflammatory disease
CASE 8.—B. B.	72 year woman
Clinical:	Progressive weight loss, nausea, and anorexia for one year; hemoglobin 8.8 gm.
X-ray:	Extrinsic pressure deformity against the rectosigmoid displacing that structure to the right; intrinsic colonic abnormality not thought to be present (Fig. 4*B*)
Operation:	Preoperative diagnosis was endometriosis plus pelvic inflammatory disease; at operation a perforating carcinoma of the rectosigmoid colon was found which was resected
Pathological examination:	Perforating adenocarcinoma of the rectosigmoid colon

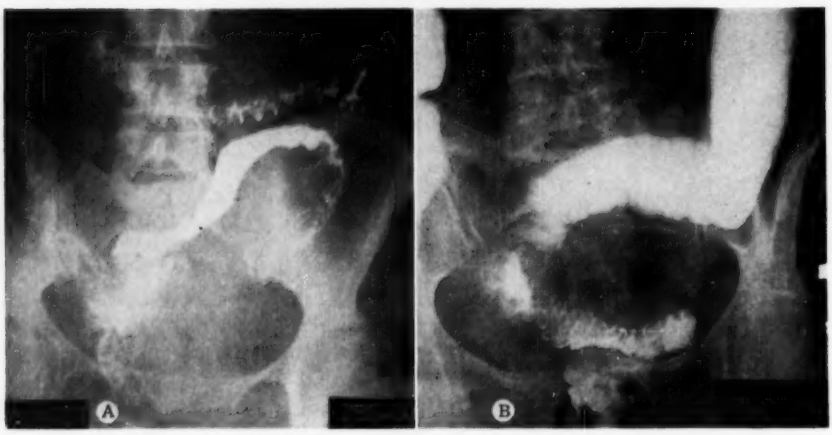

Fig. 4.—Roentgenograms showing (*A*) endometriosis displacing sigmoid colon and (*B*) perforating carcinoma of rectosigmoid.

Extrinsic lesions of the colon are easily differentiated from intrinsic ones both clinically and roentgenographically. In the former class of lesions, the colon is displaced but the mucosal pattern remains intact. Secondary involvement of the colon by extrinsic tumefaction is not uncommon, particularly in pelvic disease in females. Figure 4*A* demonstrates such a case which proved to be endometriosis with serosal infiltration of the sigmoid colon, accounting for the displacement and fixed position of the sigmoid colon. In 10 to 20% of cases of colon carcinoma, chronic perforation occurs. This will obliterate the usual characteristics of colon neoplasms. Figure 4*B* demonstrates this type of case in which the pressure of the perforated neoplasm of the rectosigmoid area upon the sigmoid colon produced an appearance of an extrinsic lesion similar to that of Figure 4*A*.

CASE 9.—G. G.	17 year girl
Clinical:	Sudden onset of left lower quadrant pain and constipation; no melena or weight loss
X-ray:	Constricted lumen involving 10 cm. of sigmoid colon with tapering edges, thought to be inflammatory (Fig. 5*A*)
Operation:	Three months after left colectomy, a similar appearance in remaining colon, 13 in. (33 cm.) proximal to the anastomosis. (Fig. 5*B*) Left colectomy; transverse colestomy three months later for frozen pelvis.
Pathological examination:	Colloid carcinoma of rectosigmoid; widespread regional metastasis

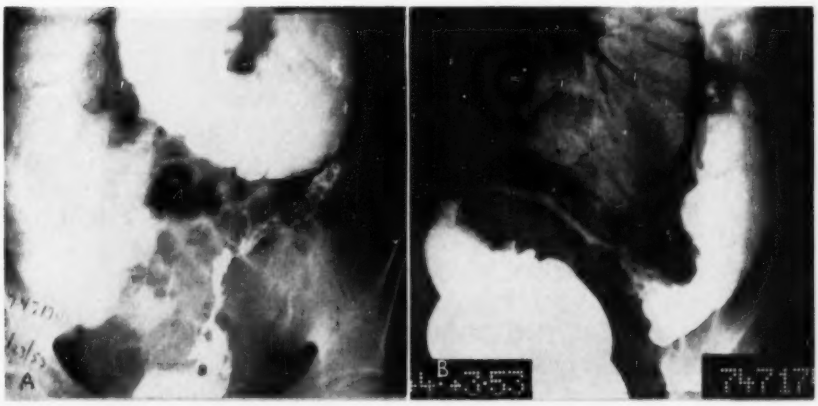

Fig. 5.—Roentgenograms showing (*A*) carcinoma of sigmoid colon and (*B*) recurrence of carcinoma of sigmoid colon.

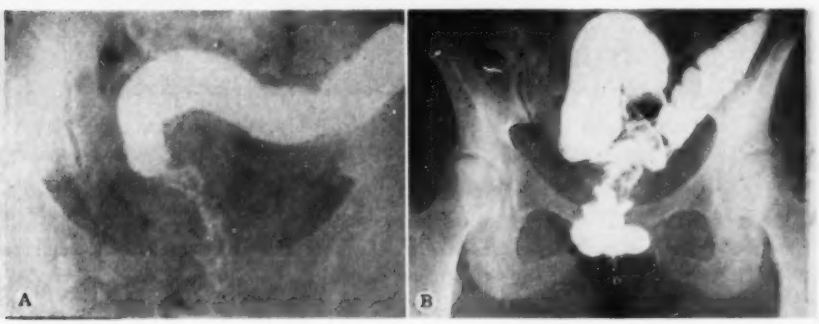

Fig. 6.—*A*, roentgenogram showing irradiation colitis, and *B*, carcinoma of rectum.

This unusual case of colloid carcinoma of the colon forms a very small per cent of malignant colonic neoplasms. This case, from the point of view of history, age group and roentgen findings, fell into the inflammatory class of lesions. Owing to the involvement of both the luminal and the serosal aspects of the colon wall by this type of neoplasm, a fairly long constricting lesion of the colon is produced

similar to the type seen in nonspecific colitis. The extensive recurrence in a three-month period also suggested an inflammatory lesion in its clinical course.

Lesions of Rectum.—

CASE 10.—C. G.	56 year woman
Clinical:	Developed rectal bleeding and diarrhea six months after radium and x-ray therapy for carcinoma of the cervix
X-ray:	Postirradiation narrowing of the large bowel for 11 cm. extending above and below rectosigmoid junction with fistulous communication to vagina (Fig. 6*A*)

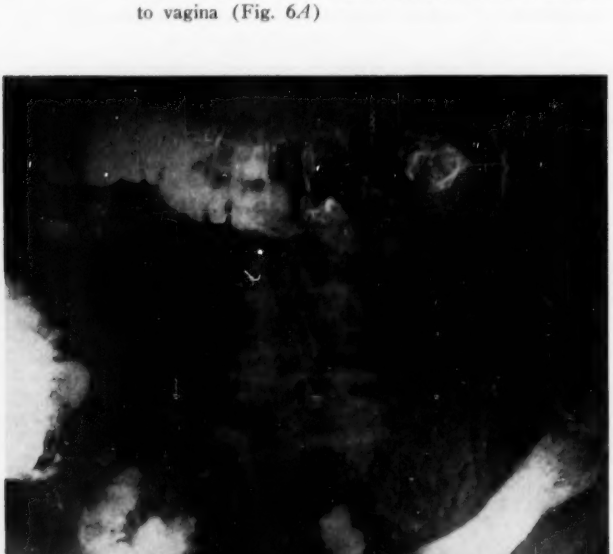

Fig. 7.—Roentgenogram showing polypus of transverse colon.

Operation:	Sigmoid colostomy
Pathological examination:	On sigmoidoscopic biopsy chronic catarrhal changes of rectum compatible with irradiation
CASE 11.—H. V.	44 year woman
Clinical:	Rectal bleeding for two years; diarrhea for one month; hemoglobin 8 gm.
X-ray:	Fairly extensive intrinsic neoplasm of rectum, demarcated above and below by carefully-defined overhanging margins (Fig. 6*B*)
Operation:	Sigmoid colostomy; neoplasm too extensive to remove
Pathological examination:	By sigmoidoscopic biopsy; adenocarcinoma of rectum

These two cases show to good advantage the difference between inflammatory and neoplastic lesions of the rectum. In Figure 6*A* the smooth, tapering edges of the inflammatory lesion as opposed to the overhanging edges of the carcinoma in Figure 6*B* is the main point in differentiation.

Polyps and Multiple Lesions.—

CASE 12.—A. D. 71 year old woman

Clinical:	Recurrent diarrhea for one year; no melena or weight loss
X-ray:	(Fig. 7) Polypoid lesion of the transverse colon undergoing malignant degeneration
Operation:	Wedge resection of the transverse colon containing the polyp
Pathological examination:	Atypical epithelial hyperplasia in a large sessile adenomatous polyp; no carcinoma

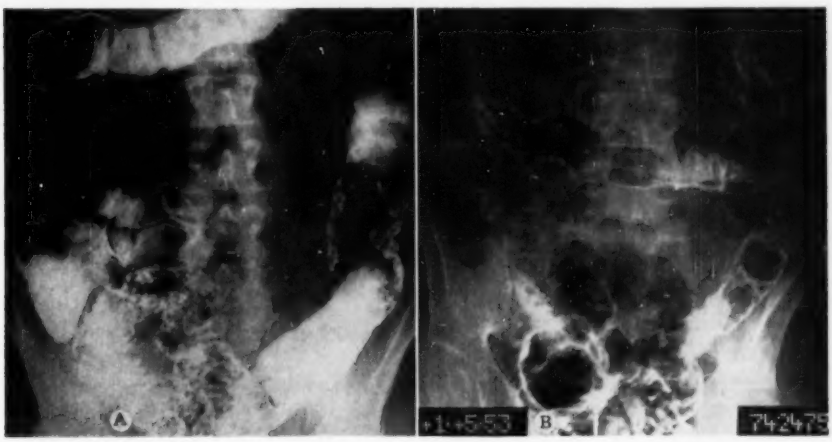

Fig. 8.—*A*, roentgenogram showing multiple polyposis and *B*, pseudopolyposis.

Irregularity and ulceration of the surface of a polypus is one of the signs on x-ray of malignant degeneration. Although no carcinoma was found in this case, the fact that atypical epithelial hyperplasia was present suggests that malignant change may have been about to occur.

Figure 8 shows two cases of polyposis of the colon; *A*, a case of congenital multiple polyposis in a 7-year-old girl, and *B*, an example of pseudopolyposis in a 28-year-old woman with chronic ulcerative colitis.

In congenital multiple polyposis, the familial history and the roentgen findings will usually establish the diagnosis. A similar x-ray picture is produced in 15 to 20% of the cases of chronic ulcerative colitis due to the regenerating tabs of mucosa which are spared by the destructive process. These tabs are termed pseudopolypi. However in such cases, the stigmata of ulcerative colitis are also found on the x-ray film: loss of haustral markings, collar button ulcerations, and shortening of the colon. The tendency toward malignant change is much greater in multiple polyposis than in pseudopolyposis.

SUMMARY

A collection of interesting cases is presented which demonstrate the similarity of findings, particularly in x-ray study of the colon, which may be present in various types of lesions of the large bowel. Although the large majority of patients with large bowel disease have sufficiently typical clinical, laboratory, and x-ray findings to enable the surgeon to make a definite diagnosis before operation, an occasional case does occur in which there are such atypical findings or conflicting ones in the various studies that the true diagnosis is not made until the diseased tissue is examined under the microscope.

Certain it is that the surgeon must diagnose and plan treatment for his patients in close cooperation with the radiologist and the pathologist if he is to offer them the best possibility for a happy outcome.

ISCHEMIA OF THE LUNG

Practical Applications in Segmental Resection of Pulmonary Tissue

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THE ABILITY of an organ to withstand partial or complete ischemia not only is of academic interest but may have practical importance. Techniques of operations in certain regions, tissue transplantations, safe timing in occlusion of blood supply, and other important clinical principles may depend upon the tolerance of the organs to total or complete occlusion of the blood supply.

Interest in transplantation of homologous lung tissue led to our original experiments on the ability of the lungs to withstand interruption of the blood supply.[1] The experiments were designed to determine the length of time the lung would remain viable after total occlusion of its circulation. The results of the original study were astonishing. In dogs, the blood supply of the lungs could be occluded for as long as 360 minutes with the survival of lung tissues. The Table reveals the duration of ischemia and the gross and microscopic changes.

One-half of the animals were given penicillin, 200,000 to 300,000 units daily, for a week after the operation. The antibiotic protection had no demonstrable bearing on the results.

The amazing survival rate, for both the whole animal and the violated organ, commanded a careful assessment of whether the total blood supply was really occluded, for our information and for skeptical readers of the report. Accordingly, the method is described.

The dogs were anesthetized by intravenous pentobarbital sodium (Nembutal), 25 mg. per kilogram of body weight. An endotracheal tube with an inflatable cuff was employed and positive oxygen insufflation of the lung maintained by a Mine Safety Device, Pneophore.

The chest was opened and the following technique employed: The pulmonary ligament was divided, the hilar pleura circumscribed, and all small vessels and nerves which were visible divided between ligatures. The pulmonary artery and veins were identified, mobilized and individually secured in continuity with a double loop of umbilical cord tape held about each vessel by a short piece of rubber tubing and fixed in position by a small hemostat (Fig. 1).

The main bronchus was occluded by the same method to insure interruption of the bronchial arteries and veins. Further insurance of total ischemia was then effected by placing a crushing tourniquet of umbilical cord tape around the entire pulmonary hilus.

From the Surgical Research Laboratory, Department of Surgery, The George Washington University School of Medicine. Supported by the Veterans Administration Contract, V1001-M-3210.

The mass ligature and the other temporary ligatures on the pulmonary artery and veins were removed at the end of the experiment and the lung inflated. The chest wall was then reconstructed.

Arterial blood oxygen samples were obtained through femoral arteries and gas samples from the Sanborn water spirometer before occlusion and after the animal breathed spontaneously after the production of lung ischemia.

It was appreciated, however, that studies on the effects on lung function after ischemia were necessary before the method could be applied safely to the human. Erratic findings after bronchospirometry in experimental animals made this method undesirable. Accordingly, the most decisive test possible for determining lung function was done. After temporary ischemia of the lungs for varying periods, the contralateral lung was removed.

Duration of Ischemia and Gross and Microscopic Changes in Dogs After Occlusion of Pulmonary Blood Supply

Animals,* No.	Blood Supply Occlusion, Minutes	Ischemic Lung	Control Lung
1	30	No change	No change
3	45	3, No change 1, Chronic pneumonitis	No change
5	60	4, No change 1, Gangrene †	4, No change 1, Pneumonitis
3	90	1, No change 2, Pneumonitis, slight	2, No change 1, Pneumonitis, slight
2	120	1, Pneumonitis, slight 1, Pneumonitis, severe	1, No change 1, Pneumonitis, severe
1	180	No change	No change
1	240	Acute pneumonitis	Acute pneumonitis
3	300	No change	No change
2	360	Thrombosis necrosis	Postmortem autolysis

* Animals were killed and autopsies were performed from 2 to 34 days after the experiment.
† There was no explanation for development of gangrene.

A total of 60 dogs was subjected to temporary lung ischemia followed by contralateral pneumonectomy. Eleven other animals were employed as controls, with only total pneumonectomy performed.

Details of this second phase of the study are too lengthy to recount fully and are not in the province of this report. It is important to record, however, that the vascular supply of the lung of the animal could be occluded for more than 45 minutes with survival after contralateral pneumonectomy. It is most significant, however, that after 30 minutes of ischemia of one lung, both immediate and late mortality following contralateral pneumonectomy doubled. It appears, therefore, that in the dog after 30 minutes of total ischemia lung function is severely impaired.

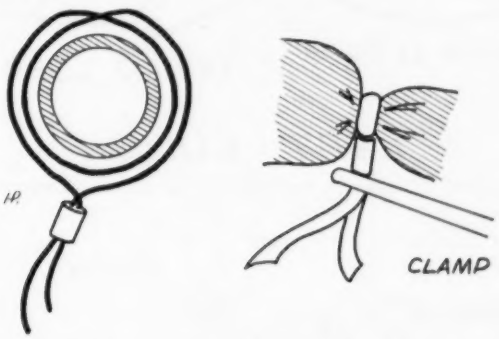
Oxygen uptake (cubic centimeters per liter ventilation per minute) and arterial blood saturation percentage indicated that the surviving animals subjected to ischemia and the control dogs subjected only to pneumonectomy fared equally well in the long-term survival.

The minimal gross and microscopic damages in the lungs of the animals subjected to ischemia suggested that the production of a bloodless field in pulmonary surgery might be feasible and, moreover, time limits of transplantations of lung tissue would be increased.

The eventual importance of these studies will be determined by the test of time and application. Possible ramifications include consideration of the ability of the lung to withstand ischemia in the designs and techniques of extracorporal circulation pumps. And in the future the information may be useful in transplantation of lung tissue. There is also the possibility of extension of tolerance to impaired blood supply of the lung with the aid of hypothermia.

The first limited clinical application based on the experiments described involved the use of bloodless fields during the performance of segmental resections. In seven cases temporary occlusion of the hilus of the lobe has been performed. In all but one case there was upper lobe disease with segmental or bisegmental resections, and in one case resection of the dorsal division of the lower lobe was done.

Factors of safety in human application of the method exceed experimental levels, since the tourniquet at the hilus is not tightened enough to occlude the bronchus,



DOUBLE LOOP LIGATURE

Fig. 1.—Technique for temporary occlusion of blood vessels.

and almost certainly there is some blood supply remaining through the bronchial arteries. An arbitrary limit of 20 minutes of occlusion was employed in human cases, and in no instance could mortality or morbidity be attributed to the temporary occlusion of the pulmonary vessels.

The bloodless field is helpful in cases with a difficult hilus, and in a few instances retrograde dissection was of distinct advantage by establishing the line of cleavage at the periphery of the segment before the segmental hilus was free.

The method has also been employed in cases of right upper lobe lobectomy with technically difficult hiluses and incomplete fissures between upper and middle lobes.

In order to have sufficient exposure of the segmental hilus in upper lobe dissections, the tourniquet must be placed about the hiluses of both upper and middle lobes (Fig. 2). For the dissection of the dorsal division of the lower lobe, occlusion of the lower lobe of the hilus is sufficient (Fig. 3).

Experimental evidence indicates that the technique is safe, if the necessity for the occlusion of the entire pulmonary hilus should be indicated.

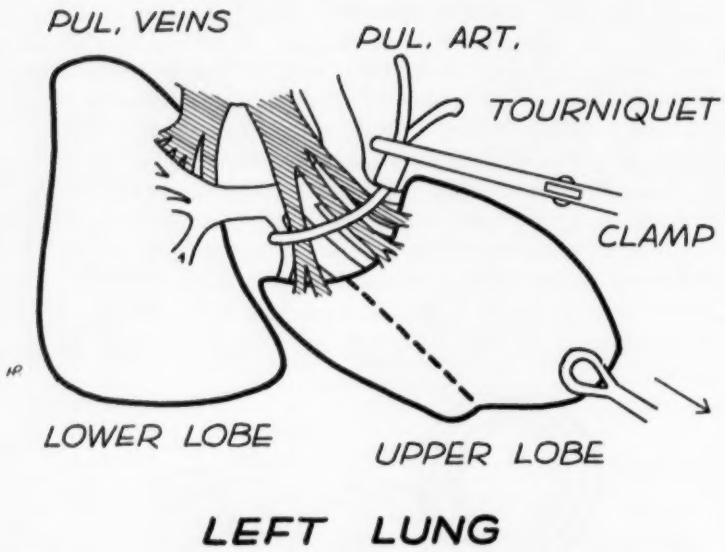


Fig. 2.—Position of tourniquet about middle and upper lobe pulmonary hiluses.

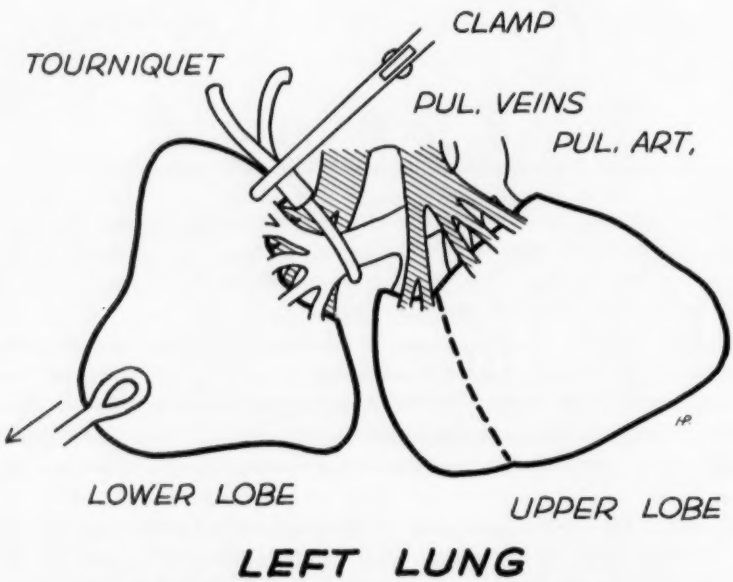


Fig. 3.—Position of tourniquet for lower lobe operations.

CONCLUSIONS

The lung is a primitive organ and will tolerate interruption of its blood supply for surprisingly long periods.

The differential between anatomic change and function is quite different. After 30 minutes of ischemia, lung function is seriously impaired.

The practical application involves the production of a bloodless field for the performance of segmental resections in technically difficult cases.

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SUCCESSFUL RESECTION OF SPLENIC ARTERY ANEURYSM

Suggestion as to Technique in Surgical Management

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ALTHOUGH aneurysm of the splenic artery has been known for some 100 to 110 years, its occurrence is so uncommon that no one surgeon's experience with the lesion can be wide. The autopsy incidence has been reported between 0.02% (4 in 19,300 autopsies — Schroetter) and 0.2% (7 in 3,108 autopsies — Bosdorf).[1] Yet the lesion is of great significance, as evidenced by the fact that until 1942, of 124 reported cases, there had been but 20 survivals.[8] It is also estimated that about one-third of all splenic aneurysms will rupture in time if left untreated.[1] On this account, it would seem wise that cases be reported so that everyone may be as familiar as possible with the condition and the problems of its surgical therapy.

In addition to presenting one case of large aneurysm of the splenic artery, we feel that the principle of dissecting in the plane of the pancreatic capsule rather than close to the aneurysmal wall is worthy of note. Most authors feel that these lesions are in some way related to preexistent arteriosclerosis, syphilis, or trauma. The presence of any of one of these conditions means that the vessel wall does not have its normal strength and elasticity. There is less danger of rupture during the procedure, therefore, if the dissection is slightly away from the aneurysmal wall. Of necessity, with the course of the splenic artery along the upper border of the body and tail of the pancreas, many of these lesions will penetrate the organ yet rarely involve the vital head. It had been previously shown that if the short gastric vessels are not disturbed, splenectomy is not essential in the removal of the aneurysm.

REPORT OF A CASE

A 51-year-old white man was admitted to the North Carolina Baptist Hospital because of a "knot in the stomach" and spells of weakness and nervousness often accompanied by vomiting. These symptoms had been present for some two years. About three months prior to admission he had suffered severe epistaxis, necessitating transfusion, and had been found to be hypertensive. After this episode he noted tarry stools on at least two occasions but had no hematemesis. While in the hospital, he had episodes of severe abdominal pain with radiation into the back, requiring narcotics for relief.

Examination revealed a thin, well-developed, white man appearing about his given age. Blood pressure was 194/120. The heart was not grossly enlarged, and no murmurs were heard. In the left upper quadrant was a smooth, tender, pulsatile, 6 by 5 by 4 cm. mass over which a systolic bruit was easily audible. Pressure on this mass did not alter the radial pulse or the blood pressure. The remainder of the examination was not of note.

Chest x-rays, electrocardiogram, routine blood count, urinalysis, and serologic studies were all within normal limits, perirenal air insufflation, barium enema, and translumbar aortography were also reported as unrevealing. This last procedure, however, did not give good filling of all branches of the celiac axis. Amobarbital (Amytal), phentolamine (Regitine), glucose tolerance, and piperoxan hydrochloride (Benzodioxane) tests were all relatively normal. Upper gastrointestinal x-rays showed displacement of the stomach anteriorly and to the left. The serum amylase was 383 units, and the stool was strongly positive for occult blood.

Fig. 1.—Unopened specimen.

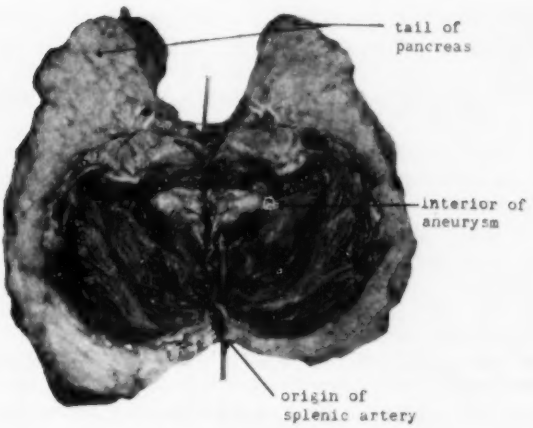

Fig. 2.—Hemisection of specimen.

A presumptive diagnosis of essential hypertension and aneurysm of the splenic artery was made in spite of the aortogram, and celiotomy was performed. This was done through a long left paramedian incision with an extension running obliquely upward and medial to just above the xiphoid in anticipation of removing the xiphoid if this proved necessary. Examination of the abdominal viscera revealed an 8 cm. aneurysm of the splenic artery which had penetrated the substance of the body of the pancreas. The aneurysm arose barely 1 cm. from the origin of the splenic artery at the celiac axis. It was in intimate contact with the inferior vena cava for several centimeters and was attached to the posterior wall of the stomach. The stomach was separated from the aneurysm by blunt and sharp dissection, the adhesions being avascular save for one small area. Dissection was then begun on the medial surface in an attempt to free up

and ligate the splenic artery proximal to the lesion. This was extremely difficult, and it was found that the hepatic and superior mesenteric arteries were pushed upward and to the right. As well, the lesion was intimately fused with the upper border of the body of the pancreas. At its lower border it was adherent to the vena cava. The body and tail of the pancreas were then mobilized integrally with the aneurysm. In this manner, the aneurysm and pancreas could be drawn upward and to the right, enabling the lesion to be separated from the vena cava by sharp dissection. When this was accomplished, it was possible to place a single clamp across the splenic artery just proximal to the aneurysm. The stump was secured with a continuous mattress suture of arterial nonabsorbable surgical (silk) suture material just beneath the clamp and flush with the origin of the superior mesenteric artery. The pancreas was then divided approximately at the junction of the body and the head and the stump closed with inverting horizontal mattress sutures of silk. The splenic vein was divided between ligatures and the splenic artery distal to the pancreas clamped, divided, and tied. The specimen, consisting of the aneurysm and body and tail of the pancreas, was thus removed. The spleen was not removed, as the short gastric vessels were not disturbed.

The patient's postoperative course was entirely uneventful. The stools became negative for occult blood within a few days, and the serum amylase fell to within normal limits. The patient's hypertension persisted unchanged, but he became asymptomatic.

SUMMARY

An additional case of aneurysm of the splenic artery is reported. The suggestion is made that in surgery of the larger lesions which have penetrated the substance of the pancreas the dissection be carried out in the plane of the pancreatic capsule rather than close to the aneurysmal wall.

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SURGICAL ASPECTS OF PERIARTERITIS NODOSA

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WITH REPORTS of possible cures or prolonged remission of periarteritis nodosa with cortisone or corticotropin therapy, the early diagnosis of the disease becomes of greater significance. Either there is an increase in the frequency of the disease, or the increased awareness of the disease is resulting in more frequent diagnoses. Although the collagen diseases remain poorly understood, some progress is being made as the clinically benign forms of the disease are being separated from the severer forms.[2] This progress may be enhanced by additional case reports of clinical and pathological findings.

The surgeon is interested in this disease from several standpoints. The gastrointestinal tract is involved by this disease in 50 to 56% of the cases.* Hematemesis or melena occur in 18% of the cases. It should, therefore, be considered in the differential diagnosis of other surgical diseases of the abdomen. It is frequently the surgeon who is initially aware of this disease in early cases, either from laparotomy for abdominal pain or from skin and muscle biopsy, at the request of the internists.

At this hospital, five patients with lesions consistent with periarteritis were seen during the past year. A sixth patient was treated here in 1951. All were admitted with a chief complaint of abdominal pain. Four of the five patients underwent operation with the preoperative diagnosis of acute appendicitis and one with the preoperative diagnosis of acute cholecystitis. Specimens removed at operation revealed arterial lesions consistent with periarteritis nodosa.

Whether periarteritis limited to the appendix is the same disease as that described by Kussmaul and Maier [5] in 1866 is open to question. The disease to which Kussmaul applied the name of periarteritis is one in which all layers of the medium-sized arteries are involved in a process of necrotizing, exudation, and productive periarteritis. Clinically, the disease affects numerous organs, causing infarcts of the gastrointestinal tract, heart, and kidneys, but not of the lungs. Periods of remission may occur, but the outcome is usually fatal, within a month to two years after symptoms occur. Whether or not the clinical picture is consistent, the pathological changes in the arteries are the same when the disease is limited to the appendix alone. Plaut [7] presented 88 cases, which he collected over a period of 22 years, in which the pathological sections of the arteries of the appendix were typical of periarteritis nodosa. In all these cases the postoperative course was uneventful recovery, with no recurrence of signs or symptoms of periarteritis. Hall and associates [4]

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* References 1 and 4.

presented 22 similar cases, with shorter follow-up observation. On the other hand, of 30 autopsies done at the Mayo Clinic on patients who had died of periarteritis nodosa, 2 showed appendiceal involvement.[7]

Since the etiology of both types of the disease remains unknown, no analogy can be drawn as to the cause. Another problem is presented in differentiating the disease of Kussmaul and Maier from that of Plaut—if they are separate entities: Since periarteritis causes abdominal complaints, how is one to rule out the severer form of the disease when the pathological section is reported as periarteritis nodosa? Whereas the cases presented here do not answer this question, they do present the problem faced by the clinicians when the diagnosis is made by the pathologist on specimens removed at surgery.

REPORT OF CASES

CASE 1.—A 21-year-old white man was admitted on Jan. 12, 1953, with an eight-day history of fever and diarrhea. Two nights prior to admission, he had begun vomiting and had developed cramping lower abdominal pain, which had persisted until he was admitted. The past history was significant in that the patient had had generalized angioneurotic edema in 1948.

Physical examination showed a well-developed, well-nourished white man who appeared to be in severe distress from abdominal pain. Temperature was 100.8 F. Abdomen was soft, with diffuse lower abdominal tenderness. Remainder of physical examination was essentially negative. Initial blood count was 15,000 W. B. C., with 75% neutrophiles, 17% lymphocytes, 6% monocytes, 1% basophiles, and 1% eosinophiles; hemoglobin, 14.0 gm. per 100 cc.; sedimentation rate, 34 mm. in one hour.

He continued to vomit and to have severe lower abdominal pain, which was more pronounced in the right lower quadrant. Acute appendicitis could not be ruled out; so an appendectomy was performed. A grossly normal appendix was found. On microscopic examination, however, the medium-caliber arteries in the mesoappendix exhibited inflammatory changes in all layers of the walls, typical of periarteritis nodosa. The Fourth Medical Field Laboratory concurred in the diagnosis of periarteritis nodosa. The patient continued to have generalized pain, especially in the abdomen, back, and joints. Fever, anorexia, and vomiting continued. Biopsy of back muscle was performed but revealed only normal muscle tissue. The patient was started on cortisone therapy on Jan. 23 and continued until Jan. 29, when he was returned to the Zone of the Interior.

Follow-up report from the hospital in the Zone of the Interior to which patient was transferred stated that he ran a typical course of polyarteritis nodosa. He manifested persistent leucocytosis, elevated sedimentation rate, and pyuria, which responded to antibiotics. On Feb. 12 another course of corticotropin was started. On March 17 glycosuria developed, and a fasting blood sugar of 764 mg. per 100 cc. was obtained. Corticotropin was discontinued and insulin started. By April 7 he complained of much pain, and, as his downhill course seemed to be much faster when he was not on cortisone or corticotropin, this therapy was resumed. Blood pressure was persistently elevated to about 150/110. On April 28 he became irrational and gradually lapsed into coma, which persisted for four days. His course continued downhill, and he died June 2, 1953. Autopsy demonstrated generalized polyarteritis nodosa.

CASE 2.—A 22-year-old white man was admitted on July 30, 1953, with the diagnosis of appendicitis. He gave a history of pain in the right lower abdominal quadrant for the previous three days. The pain was increasing, and nausea and vomiting occurred; he was therefore transferred to this hospital. Past and family histories were noncontributory.

Physical examination revealed a well-developed and well-nourished man complaining of severe abdominal pain. The chest was normal. There was marked tenderness and muscular guarding in the right lower quadrant, especially over McBurney's point. Slight rebound tenderness was noted. Routine laboratory studies were within normal limits.

Appendectomy was performed on July 30, with the removal of a grossly normal appendix. The histological examination revealed acute arteritis, with necrotizing of the mesoappendiceal arteries. The Fourth Medical Field Laboratory concurred with the diagnosis of acute necrotizing arteritis of the appendix. Repeated postoperative blood studies gave no abnormal findings.

Sedimentation rate was repeatedly normal. It was felt that cortisone treatment was indicated; so on Aug. 15 he was started on 300 mg. daily, the dose being reduced to 150 mg. daily on Aug. 19 and to 100 mg. from Aug. 25 to 31. He remained asymptomatic during treatment. Blood pressure and temperature were within normal limits, except for a minor elevation of temperature during the first three days of cortisone treatment. In September he was returned to duty, and on the last follow-up, in November, he remained asymptomatic.

Case 3.—A 23-year-old white man was admitted on April 19, 1953, with a history dating from August, 1952. At that time he had noted severe headaches, chills, high fever, generalized aches and pains, and severe pain in the abdomen and in both calves, especially the left. For that reason, he had been hospitalized from Aug. 24 until Sept. 30, 1952. During that time he had lost 25 lb. (11.3 kg.). He had a marked leucocytosis, but the leucocyte level had gradually decreased to normal. The sedimentation rate had been persistently elevated. Biopsy of gastrocnemius muscle had been performed, the result of which at that time had been reported as nonspecific arteritis, acute. The temperature had decreased to normal after chlortetracycline (Aureomycin) and streptomycin therapy, and patient had been sent to duty. For about two to three weeks after discharge he felt very weak and still had aching leg muscles and headache. Then he started to feel better and gained 10 lb. (4.5 kg.). He felt relatively well until three or four days prior to this admission, when he noted severe abdominal pain and pain in his left testis. Slides of the biopsy specimen of muscle, done in September, 1952, had been sent to the Armed Forces Institute of Pathology, where the diagnosis of periarteritis nodosa was made. Because of this report and patient's symptoms, he was readmitted. An appendectomy had been done when he was 12 years old. Family history was significant in that both parents had died of carcinoma.

Physical examination showed that he was an obese white man appearing to be in moderate distress because of abdominal pain. Heart and lungs were unremarkable. There was marked point tenderness in the middle lower abdomen and both lower abdominal quadrants. Moderate tenderness was present in both inguinal regions. The right testis was atrophic. Left testis was normal in size but moderately tender. The prostate was slightly tender but not enlarged. Rest of physical examination was essentially negative. Laboratory findings were unremarkable except for 28% eosinophilia. EKG was within normal limits.

Patient's abdominal pain subsided after several days of hospitalization. However, he then developed a diarrhea, which persisted for about one week in spite of symptomatic treatment. A proctoscopic study and several stool examinations proved negative. In view of the pathological diagnosis of periarteritis nodosa, it was decided to return the patient to the Zone of Interior for initiation of treatment and further inspection.

On follow-up report, pinworm infection was discovered and treated. He remained asymptomatic, and the increased eosinophile count returned to normal. A repeat gastrocnemius muscle biopsy, done while he was asymptomatic, showed no abnormal lesions. In June, 1953, he was returned to duty and is still on active duty in the Army.

Case 4.—A 23-year-old Negro man was admitted on Dec. 13, 1952. He felt well until 10 days prior to admission, when a sudden pain developed in the lower back, radiating to both flanks and to his abdomen. One day prior to admission, he had had severe pain in the right renal area, radiating to the anterior abdominal wall but not to the testis. There was nausea and emesis. His temperature ranged from 99 to 101 F. the day prior to admission. On admission he had severe pain in both flanks and left upper quadrant. He had had no bowel movement for two days but had passed flatus. Past and family histories were noncontributory.

On physical examination, he appeared acutely ill and in marked distress. There was generalized tenderness over the abdomen but no rebound tenderness. Slight resistance was noted over the lower right rectus muscle. The remainder of physical examination was essentially negative. White blood cell count on admission was normal but varied on repeat counts to as high as 29,000. Urinalysis consistently showed pus cells and occasional red cells, with a trace of albumin.

He continued to complain of severe abdominal pain, and the spasm over the right lower quadrant remained. On Jan. 9, 1953, an abdominal exploration and appendectomy were done, with findings of mesenteric lymphadenopathy, an enlarged kidney, and multiple old adhesions in the appendiceal region. Sections of the mesoappendix revealed inflammatory and thrombotic lesions of the arteries compatible with periarteritis nodosa. The Fourth Medical Field Laboratory

concurred in the diagnosis of periarteritis nodosa. The patient was returned to a hospital in the Zone of Interior, where his course continued downhill until Feb. 21, when he died.

CASE 5.—A 46-year-old white man was admitted Jan. 15, 1954, with a history of excellent health until Nov. 18, 1953, at which time he had developed a chest cold, with generalized aching pain, weakness, and a productive cough. The cough improved, but he generally felt more lethargic and began to have shortness of breath on exertion. On Dec. 27 he began to have right upper quadrant, right lumbar, and right shoulder pain. Barium enema and gastrointestinal series were done prior to admission here and were reported as normal. Cholecystogram showed no filling of the gall bladder.

On physical examination he appeared both chronically and acutely ill. Temperature was 100 F. There was marked tenderness and rebound tenderness in the right upper quadrant. It was thought that a tender mass, probably gall bladder, could be palpated, extending from beneath the right costal margin.

Urinalysis, hemoglobin, Van den Bergh reaction, cardiolipin test, and N. P. N. were normal. White blood cell count was 13,500, with 88% neutrophiles, 9% lymphocytes, 2% monocytes, and 1% eosinophiles. Cephalin flocculation was negative, and thymol turbidity was 2.4 units.

On the day after admission, the pain became severer and the tenderness worse. A diagnosis of empyema of the gall bladder was suspected. At operation, however, the gall bladder appeared normal, but the liver was found to be enlarged and firm. Liver, skin, and muscle biopsy specimens were taken. The liver specimen showed inflammation and focal necrosis with fatty metamorphosis. The muscle biopsy specimen, taken from the abdominal wall, demonstrated microscopically all the characteristics of periarteritis nodosa.

Patient's condition began to deteriorate postoperatively, with a rise in N. P. N. and with mental confusion. He was started on intravenous injections of cortisone, with marked improvement in mental status and in symptoms. While still on cortisone therapy he was transferred to the United States on the 14th postoperative day.

COMMENT

The pathological slides in all the above cases were examined by the pathologists at this hospital, and then sent to the Fourth Medical Field Laboratory for confirmation, and some were sent to the Armed Forces Institute of Pathology. Figures 1 through 4 are photomicrographs of the involved arteries in Cases 1 through 4.

Whether Case 2 is an example of Plaut's localized disease cannot definitely be proved at present. However, his present course would lead one to believe so. If Plaut's theory of a localized allergic phenomenon to material in the appendix as the causative agent for focal arteritis limited to the appendix is true, why could not a similar process occur elsewhere in the gastrointestinal tract? One may assume that the finding of a panarteritis such as has been described under the name of periarteritis nodosa is not always a separate disease entity but may also be a nonspecific response to various etiological factors.

Corticotropin therapy of periarteritis nodosa should be initiated early, if remission or cure is to be anticipated. This therapy is not without danger, and if one could separate the different forms of the disease, one certainly would not advocate this form of management routinely. However, since the separation of true periarteritis nodosa cannot be made pathologically or clinically in the early stages from the localized, or more specific, type, should one not give a course of corticotropin routinely in all cases in which the diagnosis has been made? If this conclusion is valid, every surgeon should be aware of the pathological findings of this disease, and he should look for them each time he does a laparotomy when other pathology is not present. It is now routine at this hospital, except in cases of definite acute appendicitis, to examine the mesentery of a large segment of the small intestine

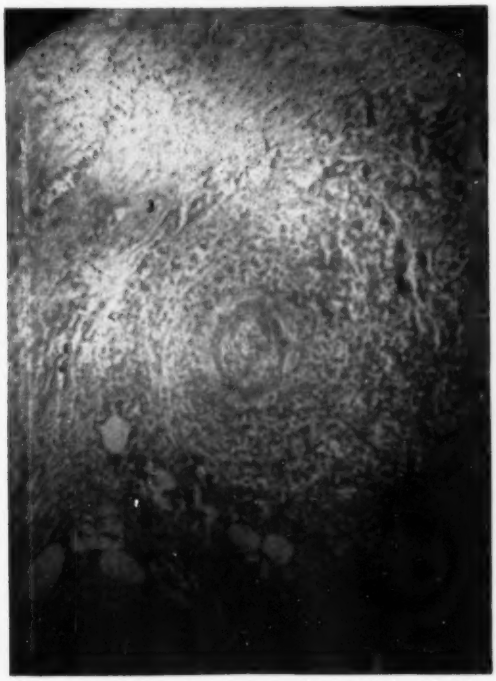

Fig. 1.—Photomicrograph of artery in mesoappendix of Patient 1. Magnification × 13.

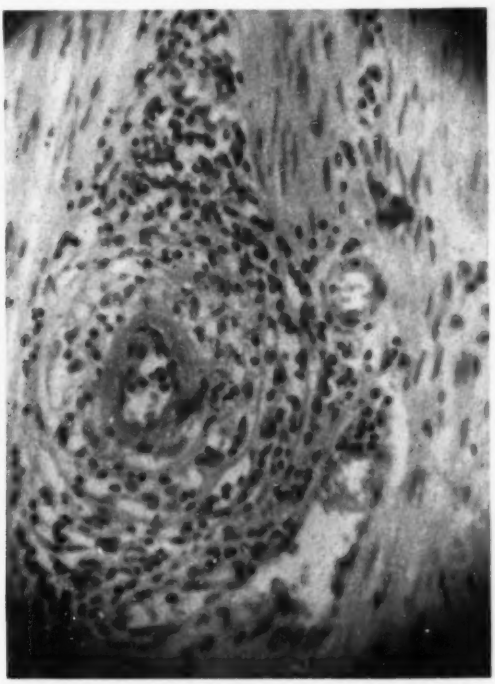

Fig. 2.—Photomicrograph of artery in mesoappendix of Patient 2. Magnification × 30.

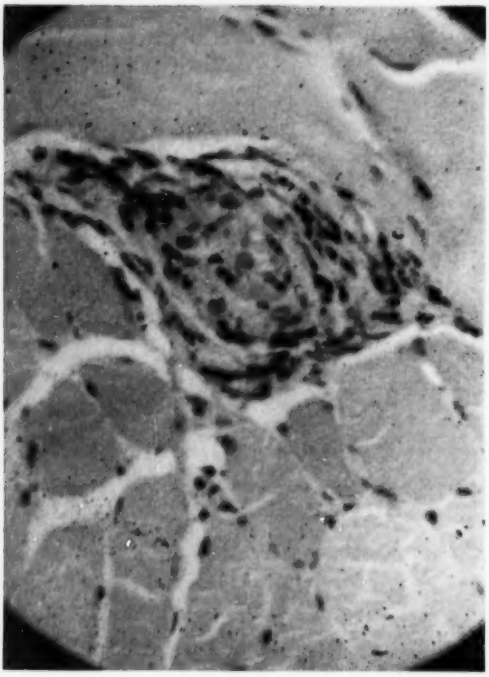

Fig. 3.—Photomicrograph of artery in mesoappendix of Patient 3. Magnification × 37.

Fig. 4.—Photomicrograph of artery in mesoappendix of Patient 4. Magnification × 7.

for signs of periarteritis and to obtain a biopsy specimen if suspicious lesions are found. The gross findings consist of nodular masses surrounding the medium-sized arteries of the mesentery. The finding of these local lesions in the mesoappendix should not be relied upon as diagnostic of generalized periarteritis, but this finding should make one suspicious, and supplementary gastrocnemius muscle biopsies should be done prior to initiating corticotropin management.

SUMMARY

Periarteritis nodosa should be included in the differential diagnosis of abdominal disease, as abdominal complaints are frequently the first sign of the disease. For this reason, the surgeon should be aware of the disease and recognize his responsibility in making the diagnosis, so that early treatment may be initiated.

Five cases with lesions consistent with periarteritis nodosa are presented. Three were diagnosed from appendectomy findings, one from specimens removed during exploratory laparotomy, and one from muscle biopsy tissue. Four received cortisone or corticotropin. At the time of this report three patients were alive, and two had died of the disease.

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IMPORTANCE OF SKIN TOWELS IN ORTHOPEDIC OPERATIONS

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IT IS ACCEPTED and current practice in orthopedic surgery to apply towels or other sterile material to wound edges during an operation. These sterile towels, clipped securely to the edges of the wound, are presumed to diminish the chances of wound contamination and, hence, of wound infection. At the Wadsworth General Hospital, Los Angeles, it was decided to test this concept.

TABLE 1.—*Differences in Number of Colonies Developing Without Towels, with Mean Difference and Standard Deviation of the Mean**

Frequency Z	Deviation from Origin, X	Z_x	Z_{x2}
1	— 6	— 6	36
1	— 4	— 4	16
1	— 3	— 3	9
5	— 2	—10	20
5	— 1	— 5	5
34	0	....	..
8	1	8	8
3	2	6	12
1	4	4	16
1	10	10	100
1	14	14	196
1	22	22	484
1	75	75	5,625
63	....	111	6,527

* Mean difference in number of colonies $= \frac{\text{Sum (Zx)}}{\text{Sum (Z)}} = \frac{111}{63} = 1.7$ colonies; standard deviation $= \pm 10.3$.

METHOD

Every major "clean," noninfected operation for a four-month period in 1953 was subjected to a study by wound culture during the progress of the surgical operation and by follow-up study of the incidence of infection. Operations were performed by some operators using towels and towel clips securely fastened to the wound edges and by others with no toweling whatsoever. Preparation of the skin previous to the surgery in all operations was identical. A sterile swab was placed into the wound immediately after the incision was made, and a second swab was rubbed into the wound one hour after the operation had started. The swabs were cultured on agar plates. Results are shown in Tables 1, 2, 3, and 4. Cultures were obtained in 92 cases with, and 81 cases without, towels. Not all cases could be used, as the Tables indicate. Some were not included because one of the two swabs at operation was omitted. Others were omitted because

the number of bacterial colonies on the plate was too numerous to count. Since all cases were consecutive, instances that could not be used in the statistical evaluation were about the same in the two series.

The mean difference in the number of colonies after one hour of surgery and the standard deviations were calculated according to the method of Pearl.[2]

TABLE 2.—*Differences in Number of Colonies Developing with Towels, with Mean Difference and Standard Deviations of the Mean**

Frequency Z	Deviation from Origin (0) X	Zx	Zx2
1	— 7	— 7	49
1	— 5	— 5	25
3	— 2	— 6	12
8	— 1	— 8	8
33	0	0	0
8	1	8	8
4	2	8	16
4	3	12	36
3	5	15	75
1	11	11	121
1	13	13	169
1	34	34	1,156
1	57	57	3,249
1	60	60	3,600
70	....	218	8,524

* Mean difference $= \frac{\text{Sum (Zx)}}{\text{Sum (Z)}} = \frac{218}{70} = 3.10$ colonies; standard deviation $= \pm 10.8$.

TABLE 3.—*Increase in Number of Colonies After One Hour*
(Summary of Tables 1 and 2)

	Mean Increase in Colonies	Standard Dev. of Mean
With towels, no.	3.1	10.8
Without towels, no.	1.7	10.3

TABLE 4.—*Incidence of Infection in Ninety-Two Cases with Towels and Eighty-One Cases Without Towels*

	Cases With Towels, No.	Cases Without Towels, No.
Frank infection	2	1
Slight drainage	7	1

RESULTS

Several observations may be made. First, the number of colonies does not seem to be influenced by the presence or absence of towels clipped or sewn to the wound edges. Second, in most cases, there were no bacteria grown from swabs taken from any of the wounds. The mean values are close together (3.1 and 1.7 colonies) and the standard deviations overlap completely, indicating no significant difference between the two groups.

Girdlestone, Bourdillon, and McFarlan [1] conducted a similar experiment at Oxford in 1951. They could arrive at no conclusion, since the number of cases was too small.

In this series, there were three frank infections postoperatively and eight instances of slight drainage. The remainder of the wounds healed per primum Skin towels were used in two of the frank infections and in seven of the cases that resulted in slight drainage.

In two other cases, an attempt was made to determine whether or not there was any histologic evidence of an inflammatory reaction in the skin as a result of the towel clips. One side of the wound had towels and towel clips, and the other side had none. At the end of the operation, a thin strip of skin was removed from the wound edges. There was no evidence of an inflammatory reaction in any part of the wound edge on either side.

It should be emphasized that these patients were operated upon by different surgeons, some clipping towels to the wound edges, others not doing so. Additional controls would have been present if all of the surgeons had clipped towels to the wound edges in alternate cases.

SUMMARY

A study was undertaken to determine the importance of clipping skin towels to the edges of wounds during the course of orthopedic operations. One hundred and seventy-three consecutive major operative cases were used for analysis. In 92 cases, towels were used; in 81, the area was merely draped. Bacteriological analysis was completed on 70 of the group with towels and on 63 patients without towels. Contamination with bacteria was about the same in the two groups. There was no greater incidence of postoperative infection in the group in which towels were clipped to the wound edges than there was in the group in which no towels were used.

Dr. L. Kaplan, Chief of the Laboratory Service at Wadsworth General Hospital, and Dr. Robert Hoyt, of the Cedars of Lebanon Hospital, provided the bacteriological and statistical analysis of this study.

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TREATMENT OF OSTEITIS PUBIS WITH CORTICOTROPIN AND CORTISONE

Report of Two Cases

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THE TREATMENT of osteitis pubis is in the process of being changed at the present time. After the introduction of retropubic surgery into this country, by Dr. Terrence Millen, the number of cases of osteitis pubis reported in the literature appeared to increase. In many clinics, however, the operation was gradually abandoned because of this painful complication. Treatment, for the most part, was symptomatic, and the results were not satisfactory. In 1946 corticotropin (ACTH) was introduced into medicine for the treatment of rheumatoid, arthritic, and allied diseases. Soon thereafter cortisone was introduced by Kendell and Hench for the treatment of similar diseases. The recent application of these two drugs in the therapy of osteitis pubis has given promise of miraculous results, and it is hoped that this painful and incapacitating disease will eventually be controlled before it becomes disabling.

The etiology of the disease is unknown, but it is believed to be an inflammatory lesion which involves the structures of the anterior pelvic girdle. The periosteum, cartilage, bone, and ligamentous structures may be affected. It occurs in males predominantly, following prostatectomies, but it may occur in women who have had operations upon the bladder. Beer, who first described the disease, and others believed that the complication occurred only in cases in which the bladder was opened in the presence of infected urine. However, there are reports of cases following pyelonephritis, perineal prostatectomies, and transurethral resections in which there has been extravasation of urine. It may also follow painful deliveries and symphysiotomies. Wheeler thought it was noninflammatory and compared it to Sudeck's atrophy of bone. Lavelle and Hamm explain it as a chronic inflammatory disease of bacterial origin and were able to culture Pseudomonas aeruginosa in two cases and Proteus vulgaris in one case.

The clinical picture may appear to be mild or severe, insidious or fulminating and may appear within three weeks to four months after surgery. Invariably the first complaint is pain in the region of the symphysis pubis. As the disease progresses, pain may spread to the abdomen above the symphysis or to the inguinal areas. Later, as the ischia become involved, there is pain in the hips, perineum, buttocks, or inner aspects of the thigh. Walking is characterized by a waddling gait; sitting and bending become increasingly difficult and in some cases impossible.

The symphysis is extremely tender to touch, and any motion is accompanied by excruciating pain. There is spasm of the involved muscles and tenderness over the adductor muscles of the thighs. Micturition, defecation, and sneezing are unbearable. The temperature and white blood cell count may be elevated. Symptoms regress slowly over a period of from weeks to months, and complete recovery is the rule.

The pathological changes vary from a mild periostitis to extensive necrosis of cartilage and bone. Biopsies taken at operation appear to be yellow and gritty and contain irregularly arranged spicules of bone. Histologically, there is degeneration of hyaline cartilage and resorption of bone; there are fibrosis of the marrow spaces and a low grade inflammatory reaction, with infiltration of lymphocytes, plasma, and mononuclear cells.

Roentgenographically, no changes take place before the third week, despite the severe pain and tenderness. The earliest changes occur in the symphysis pubis, which presents a moth-eaten appearance, most marked on the medial surfaces of the joint. As the cartilage is destroyed, there is a separation of the pubis. The rarefaction continues to spread as the disease progresses and eventually involves the ischia. The lytic process is gradually replaced by recalcification, and fusion results as healing takes place. These roentgen changes may be confused with malignant changes in the symphysis.

With the introduction of corticotropin (ACTH) and cortisone, a new therapeutic weapon appeared which gave promise of miraculous results in the treatment of osteitis pubis. Dean was the first to discuss the successful treatment of this disease by the administration of corticotropin. Marshall, in 1952, reported two cures of osteitis pubis with corticotropin; the first patient received a total of 875 mg. over 11 days; the second received 1,475 mg. in 14 days. A third patient with a chronic condition treated with 1,950 mg. over 18 days showed marked improvement but no miraculous results as were demonstrated in the first two cases. Daw and Funke reported three cases successfully treated with cortisone, with complete recovery. They used 300 mg. of cortisone the first day, 200 mg. the second day, and a maintenance dose of 100 mg. daily for two weeks. All patients with acute disease treated with corticotropin and cortisone showed dramatic improvement as compared with the former methods of treatment. Pain disappeared within 24 to 48 hours, and all patients were able to get out of bed and walk without assistance. The remarkable feature of this form of therapy is that there have been no recurrences when treatment has been adequate.

The two cases here presented illustrate the therapeutic effects of corticotropin and cortisone.

CASE 1.—I. S. (16956), a 68-year-old woman was admitted to St. Clare's Hospital on June 25, 1952, with a history of sudden gross hematuria. She was taken to the operating room immediately, and cystoscopy was performed. Numerous clots were evacuated, and a large sessile tumor mass was observed on the floor of the bladder in the region of the left ureteral orifice. No attempt was made to resect the mass because of the poor condition of the patient. Bleeding points were fulgrated, and a No. 22 Foley catheter was left indwelling. Bimanual examination did not reveal any extension of the mass to the perivesical tissues.

Laboratory studies showed red blood cells 4,200,000, hemoglobin 13.6 gm., and white blood cells 9,250, with a normal differential count. The blood urea nitrogen was 16 mg. and the

blood sugar was 290 mg. per 100 cc. A diagnosis of diabetes mellitus was established which was controlled with 30 units of protamine zinc insulin and 15 units of regular insulin daily. An intravenous urogram on June 28, 1952, demonstrated normal renal function bilaterally. The defect on the left side of the bladder, produced by the tumor, was noted.

The patient was again taken to the operating room on July 3, and transvesical resection and fulguration of the tumor were performed. The postoperative course was uneventful and she left the hospital on the 10th postoperative day. The pathology report was papillary carcinoma of the bladder, Grade 11.

On July 26, approximately three weeks after the resection of the tumor mass, she developed severe suprapubic pain which radiated into both inguinal areas. The following day the patient complained of pain over the inner aspects of both thighs and was unable to walk or sit; straining at stool was unbearable. She was admitted by ambulance to the hospital on Aug. 2. Temperature on admission was 101.2 F., pulse rate 100, and respiration rate 22. Physical examination revealed marked tenderness over the symphysis pubis, and there was moderate spasm of the lower abdominal muscles. The incision was healed, and there was no evidence of fluctuation. The slightest motion in bed produced excruciating pain.

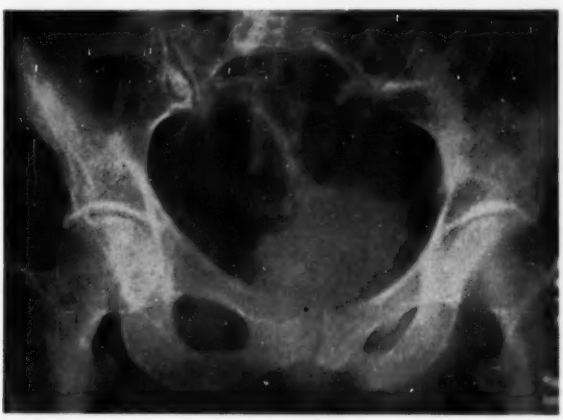

Figure 1.

The laboratory studies showed red blood cells 4,400,000, hemoglobin 13.6 gm. per 100 cc., and white blood cells 12,200, with 76% polymorphonuclear cells. The blood urea nitrogen was 17 mg. and the sugar was 124 mg. per 100 cc. The urine was alkaline and contained numerous

TABLE 1.—*Insulin Requirements During Corticotropin Therapy*

	Day																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PZI units.....	24	24	24	24	24	30	30	40	30	30	30	30	36	36	36	32	28
Reg. units.....	..	..	..	10	10	10	10	..	..	..	8	..	..	..	..	..	..
Corticotropin, mg.....	100	100	100	100	50	50	..	..	100	100	100	50	50	50	50	50	..

white blood cells. An x-ray of the pelvis demonstrated the typical moth-eaten appearance of the symphysis (Fig. 1).

The administration of corticotropin was started on Aug. 3, and 25 mg. was given intramuscularly every six hours. Two days later the suprapubic pain and tenderness were greatly diminished and the patient was able to leave her bed and walk without assistance. Her

appetite improved almost immediately and the mental depression which was characteristic on admission disappeared completely. Corticotropin was reduced to 50 mg. daily on the fifth day because of the continued improvement, and on the seventh day it was discontinued completely. After a two-day interval without corticotropin, she again complained of suprapubic pain and refused to leave her bed. Corticotropin was resumed in 25 mg. doses every six hours, and there was prompt relief from pain. After three days, the dose was reduced to 50 mg. daily, and

Figure 2.

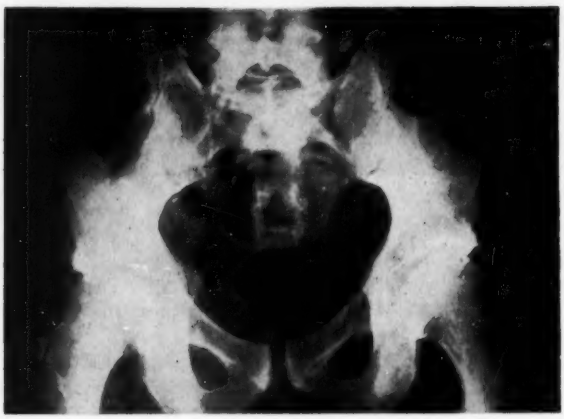

Figure 3.

she was maintained on this schedule until the day before discharge, on Aug. 20. A total of 1,150 mg. of corticotropin was given during the hospital stay. Blood sugar levels were carefully observed during treatment and insulin regulated accordingly.

In Table 1 are shown the insulin requirements during corticotropin therapy. There has been no recurrence of pain since the patient left the hospital, and she is now enjoying good health. An x-ray of the symphysis pubis one year after discharge showed complete healing, with evidence of increased bone density and bridging (Fig. 2).

Case 2.—E. M. (16832), a 73-year-old man, was admitted to the hospital on July 27, 1952, with acute urinary retention. He gave a history of difficulty starting a stream, diurnal frequency

and nocturia (three or four times); there was moderate dribbling and a diminished stream. Physical examination revealed an enlarged bladder, palpable almost to the umbilicus. The prostate was greatly hypertrophied and benign in consistency. A Foley catheter was inserted and the bladder decompressed. One week after admission, a retropubic prostatectomy was performed. Recovery was delayed because of a persistent suprapubic fistula. Three weeks later a transurethral resection of the vesical neck was performed. The sinus closed on the fifth postoperative day following this procedure. He was finally discharged from the hospital on Sept. 3, voiding a good stream and completely healed. On the eighth day after discharge from the hospital, he complained of suprapubic pain which gradually increased in severity and interfered with walking. The slightest abduction of the thighs was unbearable. Morphine sulfate, given at four-hour intervals was helpful in alleviating some of the discomfort. He was readmitted to the hospital on Sept. 21 by ambulance. The temperature on admission was 100 F., pulse rate 88, respiration rate 24. Physical examination revealed an apprehensive man who kept complaining bitterly of pain. There was marked tenderness over the symphysis pubis and spasm of the adductor muscles of the thighs. A roentgen film of the pelvis demonstrated early destruction and separation of the pubic bones.

Cortisone therapy was started immediately, and the patient received 100 mg. every 8 hours the first day; 100 mg. every 12 hours the second day, and 50 mg. twice daily as a maintenance dose for two weeks thereafter. Within 24 hours pain disappeared almost completely and he was able to move about freely in bed. The apprehension noted the day before disappeared completely. Pressure over the symphysis did not elicit pain, and he was able to move his legs freely.

TABLE 2.—*Recommended Dosage*

Corticotropin	Cortisone
1. 25 mg. q. 6 hr. for 4 days. Equivalent to 100 mg. daily	1st day—100 mg. q. 8 hr. or 300 mg.
2. 25 mg. q. 12 hr. as maintenance dose. Equivalent to 50 mg. daily	2d day—100 mg. q. 12 hr. or 200 mg.
	Maintenance—50 mg. q. 12 hr. daily for 2 wk or longer if necessary

Within 48 hours he was out of bed and walking. He appeared to gain in strength daily; appetite increased remarkably, and a general sense of well-being was observed. He was discharged from the hospital on the eighth day and told to continue the maintenance dose of 50 mg. twice daily for one week. He made an uneventful recovery and is now enjoying good health.

COMMENT

Osteitis pubis is a painful and distressing complication of lower urinary tract surgery. Our treatment of this obstinate complication is being changed at the present time with the use of corticotropin and cortisone. The amounts of drugs necessary to produce a therapeutic result have not been established, but the drugs have been effective in the doses shown.

These drugs must be used with caution. Changes in metabolism must be looked for constantly. When they are used over a long period of time, there is an increased excretion of potassium and nitrogen and retention of sodium and chloride, with resultant edema. There may be evidence of decreased carbohydrate metabolism, with hyperglycemia and glycosuria.

The relief from pain is dramatic. There is a remarkable sense of well-being; the appetite increases; patients become euphoric and interested in living again; mental depression and suicidal tendencies disappear. If the disease is diagnosed early and therapy with these new drugs is instituted immediately, we may in the future be able to affect a cure before roentgen changes take place.

SUMMARY

Two cases of osteitis pubis are presented. The first case followed suprapubic resection of a vesical neoplasm in a woman with diabetes mellitus. The dramatic effects of treatment with corticotropin and its effect on carbohydrate metabolism are discussed. The second case followed retropubic prostatectomy and transurethral resection of the vesical neck in a man. Response to cortisone was equally dramatic. Dosage and total amounts of the various drugs used are discussed. Corticotropin or cortisone may be used effectively in the treatment of osteitis pubis.

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EXPERIMENTAL AND CLINICAL STUDIES ON ARTERIAL HOMO- AND HETERO-GRAFTS PRESERVED IN ALCOHOL

Preliminary Report

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FUNDAMENTAL studies of vasal grafts have been conducted by Carrel and Guthrie,* and many others † since early this century, but it is only in recent years that this surgery has come into clinical use, thanks to invaluable work by Gross and his associates,‡ in successful experimental as well as clinical transplantation of arterial homografts. Gross stored grafts in various preservatives, including a balanced salt solution (BSS) resembling Tyrode solution at low temperature in the viable state. Swan and his co-workers § reported the successful use of a preservative consisting of Ringer's solution containing 10% human plasma. The maximum duration of grafts in these viable preservation methods, however, was about 35 to 40 days. Although these works encouraged subsequent researches a great deal, many difficulties were met and had to be overcome before these results were applicable clinically; it is difficult to obtain completely sterile material within five to six hours after death and store it in a perfect sterile state at a low temperature. Preservation requires tremendous equipment, and the material has to be tested for sterility frequently. Moreover, the duration of storage is too short for the material to be utilized in vasal transplantation, a rather uncommon operation.

More recently methods for longer preservation of the grafts have been sought experimentally by many. For instance, the transplantation of devitalized vasal grafts, especially of the ones stored in formol, had been studied for decades, rarely with success.‖ The results were not satisfactory for practical use in human surgery. The use of frozen grafts,[22] which later developed to the dry freezing method [23] and was acceptable as a safe, reliable clinical procedure,[24] has proved too costly to enable this technique to be widely employed in ordinary hospital practice.

Artificial inorganic materials for use in vasal grafting have also been investigated since the beginning of this century, and recently polythene tubing was tested by Hufnagel,[25] Moore,[26] and others, but the results of these investigations were not found to be clinically applicable.

From the Department of Surgery (Director: Prof. S. Kimoto), University of Tokyo Medical School.

* References 1 to 5.
† References 6 to 9.
‡ References 10 to 12.
§ References 13 to 15.
‖ References 16 to 21.

We and our associates have been engaged for several years in an attempt to overcome the above difficulties and establish a better method for simpler, easier, and longer preservation of vasal grafts.¶ Free venous transplantation, viable heterologous grafting, artificial tubing, and others have been fully tested. Not infrequently, successful results were obtained by each of these methods, but they were far less satisfactory than viable preserved arterial transplantation by the methods of Gross or Swan from the standpoint of safety.

Special attention was paid to devitalized grafting. Formol was also used as preservative, but it took 24 hours or longer before formol was thoroughly washed, and yet no natural softness and elasticity of the material could be regained. Besides, the material gave only very infrequent satisfactory results because of frequent occurrence of thrombi. Finally, the preservation of arterial grafts in alcohol proved to be quite successful,[29] although no reports of this method could be found in the literature.# Alcohol storage gave the same result as viable storage, not only in homografts but also in heterografts.

Results were so encouraging that the transplantation of arterial homo- and hetero-grafts preserved in alcohol was performed in 11 human cases. This, we believe, is the first successful clinical application of homo- and hetero-grafts preserved in alcohol.

EXPERIMENTS ON HOMOGRAFTS PRESERVED IN ALCOHOL

A segment of hardened arterial homograft preserved in pure or 70% ethyl alcohol (C_2H_5OH) was immersed in isotonic sodium chloride solution containing penicillin; it regained its natural softness and elasticity, thus enabling easy handling.

A dog was anesthetized with intravenous injection of barbiturate, and a portion of the abdominal aorta between the renal and inferior mesenteric arteries was resected. The defect was then bridged with the above mentioned arterial homograft. The anastomosis was made by a continuous over-and-over suture in one layer, using an Atraumatic needle with fine oiled silk. The peritoneum was reapproximated over the operative site, and the abdominal cavity was closed.

Postoperative course was observed daily by palpating the pulsating femoral artery and by taking aortograms at varying intervals. Thorough macroscopic as well as microscopic examinations were made on the dogs killed after the experiments.

RESULTS

Out of 22 dogs, on 14 experiments were made with grafts preserved in pure ethyl alcohol, on 7 with materials preserved in 70% ethyl alcohol, and on 1 with grafts preserved in 75% ethyl alcohol (Table 1). In Table 1, it is shown that the homografts kept in pure or 70% alcohol gave satisfactory results in 20 cases. In two cases, intense thromboses were observed, probably due to technical failure. The result is comparable with that of viable preserved grafts (Table 2). Attention should be called to the fact that no death occurred from disruption of the grafts.

¶ References 27 and 28.

While our studies were being conducted, an article was published by Paolucci and Tosatti [30] on experiments of transplantation of homografts stored in pure alcohol on five dogs.

MICROSCOPIC FINDINGS

Intima.—The intima of the donor vessel disappears within five days after transplantation. There is no evidence of inflammatory reaction in intima. A small thrombus appears at the site of anastomosis. By the end of the first month, the vessel regains the new intima regenerated from the host. The intima of irregular thickness gradually thins out again to its original thickness in the seventh month.

Media.—In about five days after operation, smooth muscle nuclei begin to disappear. Hyalinization of smooth muscle fibers is completed within four to six months. Elastic fibers of the donor media remain intact even one year after opera-

TABLE 1.—*Results of Transplantation of Arterial Homografts Preserved in Alcohol into Dogs' Aortas*

Dog No.	Storage Duration of Graft, Days	Alcohol Concentr.	Length of Graft, Cm.	Duration in Host Before Death, Days	Results
1 (257)	9	Pure	2.0	85	Excellent *
2 (302)	51	Pure	2.5	200	Excellent
3 (303)	60	Pure	3.5	372	Excellent
4 (304)	56	Pure	6.5	90	Good; small mural thrombus †
5 (305)	81	Pure	3.5	5	Good; small mural thrombus
6 (306)	117	Pure	4.0	12	Good; tiny mural thrombus at suture line
7 (307)	27	Pure	4.5	170	Excellent
8 (309)	53	70%	5.0	122	Excellent
9 (311)	52	70%	5.5	80	Excellent
10 (312)	58	75%	6.0	18	Good; tiny mural thrombus
11 (317)	120	Pure	6.5	6	Completely thrombosed
12 (319)	65	Pure	5.5	68	Good; small mural thrombus
13 (324)	115	70%	6.5	158	Excellent
14 (325)	46	70%	3.0	32	Good; small mural thrombus
15 (327)	176	70%	5.0	109	Excellent
16 (329)	185	Pure	3.0	15	Excellent
17 (330)	192	Pure	2.5	6	Completely thrombosed
18 (331)	67	70%	3.0	63	Excellent
19 (333)	201	Pure	2.5	7	Good; tiny mural thrombus at suture line
20 (334)	199	Pure	2.5	22	Excellent
21 (335)	118	70%	3.0	Still alive	Excellent by aortogram
22 (336)	269	Pure	3.0	Still alive	Excellent by aortogram

* "Excellent" signifies a wall with small thrombi in some part of it, while a good blood circulation was ascertained by arteriography.

† "Good" signifies a smooth wall without any thrombus macro- and microscopically.

TABLE 2.—*Comparison of Results of Homografts in Respect to Viable and Alcohol Preservation*

Method of Preservation	Success	Failure		Total
		Thrombosis	Rupture	
Arterial homografts of viable preservation	14	1	0	15
Arterial homografts preserved in alcohol	20	2	0	22

tion. They appear to be compressed because of disappearance of the smooth muscles. No fusion of the elastic tissues takes place between the donor and the recipient vessels.

Adventitia.—For five days after operation, evidence of an acute inflammation is found in the adventitia at the site of anastomosis. Marked degeneration of fibroblasts in the donor's adventitia takes place, and by the end of the third month the adventitia becomes entirely replaced by connective tissue developing abundantly from surrounding tissues.

Fig. 1.—Aortogram of a dog (No. 302) on the 200th postoperative day. Transplantation was done with use of an aortic homograft preserved in pure alcohol for 51 days. The grafted segment is shown with two arrows.

Fig. 2.—Gross appearance of the implanted aorta of the same dog as shown in Figure 1, on the 200th postoperative day.

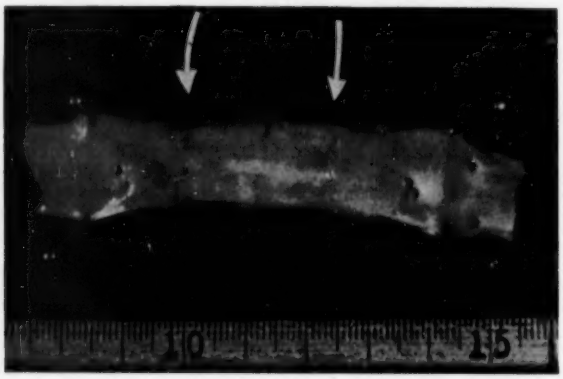

Fig. 3.—Photograph of the specimen taken out from the dog shown in Figures 1 and 2.

In short, all the transplanted vessels are replaced by the host tissues except for the elastic fibers of the media, and the replacement is completed in about three months after implantation. The elastic fibers remain at least for one year. Examples of alcohol-graft transplantation are shown in Figures 1 to 5.

As mentioned above, aortographic, macroscopic, and microscopic findings indicate that the homograft preserved in alcohol gives successful and satisfactory results,

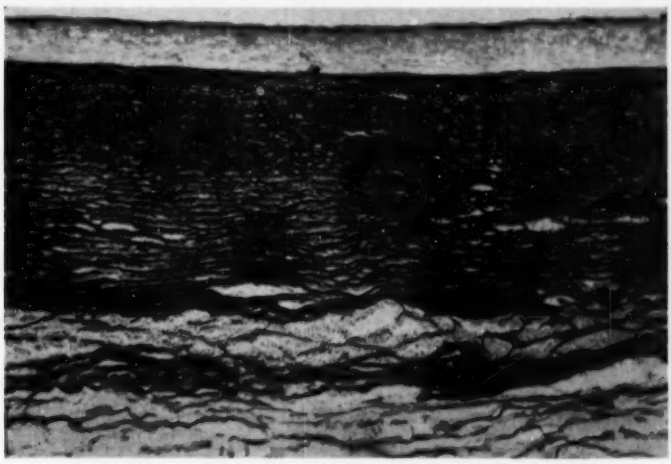

Fig. 4.—Microscopic appearance of the specimen in Figure 3.

Fig. 5.—Aortogram of a dog (No. 303) on the 372d postoperative day. Transplantation was done with an aortic homograft preserved in pure alcohol for 60 days.

comparable to those of a viable stored or freshly prepared homograft,* in reestablishing the arterial circulation. This fact leads us to believe that arterial homografts can be stored safely for a long period, at least over eight months, and then used clinically with excellent results, provided, of course, a reliable surgical technique is employed.

* Although studies of the homologous transplantation of viable stored arterial grafts were performed in detail, we do not give the results in this paper.

EXPERIMENTS ON HETEROGRAFTS PRESERVED IN ALCOHOL

The success with devitalized alcohol homografts encouraged us to make a first attempt with alcohol heterografts as well.

The transplantation of heterografts has been an interesting problem since Carrel † reported occasional success, and was repeatedly studied by various authors with only sporadic success. We also conducted experiments on this line; the transplantation of heterografts in the viable state was successful in only half of the experimental animals; in the rest of them it ended in rupture of the anastomosis. Autopsy revealed necrotic heterografts. It seemed likely that these failures might

TABLE 3.—*Results of Transplantation of Heterografts from Humans' Arteries Preserved in Alcohol into Dogs' Aortas*

Dog No.	Storage Duration of Graft, Days	Alcohol Concentr.	Length of Graft, Cm.	Duration in Host Before Death, Days	Results
1 (258)	6	Pure	3.0	18	Good; small mural thrombus *
2 (314)	8	Pure	3.0	154	Excellent †
3 (315)	20	Pure	4.0	8	Completely thrombosed
4 (316)	22	Pure	5.5	85	Good; small mural thrombus
5 (318)	66	Pure	3.0	4	Completely thrombosed
6 (320)	73	Pure	3.5	9	Excellent
7 (322)	84	Pure	3.0	69	Good; small mural thrombus
8 (323)	87	Pure	5.0	151	Excellent
9 (338)	159	70%	2.0	201	Excellent
10 (339)	167	70%	2.5	9	Good; small mural thrombus
11 (340)	168	70%	2.0	5	Excellent
12 (341)	71	70%	3.5	79	Good; tiny mural thrombus at the suture line
13 (342)	73	70%	3.0	64	Excellent
14 (343)	171	70%	2.5	18	Excellent
15 (344)	173	70%	4.0	15	Good
16 (345)	175	70%	4.0	12	Excellent
17 (346)	211	70%	8.0	32	Excellent
18 (347)	211	70%	2.0	51	Excellent
19 (348)	212	70%	2.0	Still alive	Excellent by aortogram
20 (349)	212	70%	2.0	Still alive	Excellent by aortogram
21 (350)	219	70%	5.0	74	Excellent

* "Good" signifies a wall with small thrombi in some part of it, while a good blood circulation was ascertained by arteriography.

† "Excellent" signifies a smooth wall without any thrombus macro- and microscopically.

be due to antigen-antibody reactions that could be expected in heterologous transplantation in the viable state. We thought that alcohol, through its action of dissolution of lipoproteins and denaturization of other proteins, might render the material to be grafted serologically inert.

With this as a working hypothesis, arterial heterografts were obtained from human beings within two to four hours after death, kept in pure or 70% alcohol, and transplanted on dogs.

Out of 21 dogs, the material kept in pure alcohol was transplanted in 8, and the material kept in 70% alcohol was used in 13.

The results were very satisfactory (Table 3). No disruption was observed. Postmortem examinations showed satisfactory results except in two cases in which complete thromboses occurred. Aortography in living dogs revealed that in the

† References 31 and 32.

remaining 19 cases the transplanted grafts into the aorta were patent. Although in six cases, irregularities were observed at the site of anastomosis, probably attributable to mural thrombi, these seemed insignificant, as the vessels were not noticeably narrowed. Table 3 shows that the transplantation was successful with heterografts stored for more than seven months. Histological examination revealed the same satisfactory findings as in the case of the homografts.

Parallel experiments were made with the viable arterial heterografts preserved in Ringer's solution containing 10% donor's serum and kept at low temperature. Comparison with the results obtained with heterografts preserved in alcohol (Table 4) shows that viable preservation was not as satisfactory, and four out of eight

Fig. 6.—Aortogram of a dog (No. 338) on the 201st postoperative day. Transplantation was done with a heterograft taken from human artery and preserved in 70% alcohol for 159 days.

TABLE 4.—*Comparison of the Results of Heterografts in Respect to Viable and Alcohol Preservation*

Method of Preservation	Success	Failure		Total
		Thrombosis	Rupture	
Arterial heterografts of viable preservation	3	1	4	8
Arterial heterografts preserved in alcohol	19	2	0	21

dogs died of disruption at the site of anastomosis, while there was no death due to disruption of anastomosis in the case of alcohol preservation.

Our previous assumption was thus confirmed, that even the heterograft can be safely transplanted if preserved in alcohol. Thus an arterial transplantation seems to have become a fully practical procedure, inexpensive, and not necessitating elaborate equipment and difficult techniques of preparing and storing grafts for transplantation.

CLINICAL EXPERIENCE WITH ARTERIAL HOMO- AND HETEROGRAFTS PRESERVED IN ALCOHOL

Encouraging experimental results in dogs led us to the transplantation of arterial grafts stored in alcohol in 11 human cases. As is shown in Table 5, homografts preserved in pure alcohol were used in three cases and the grafts preserved in 70%

TABLE 5.—*Clinical Cases of Transplantation of Arterial Homo- and Hetero-Grafts Preserved in Alcohol*

Case No.	Age	Sex	Disease	Source of Graft	Storage Duration of Graft	Alcohol Concentr.	Length of Graft, Cm.	Time of Arteriography (Postop. Day)	Results
1	24	F	Aneurysm of left subclavian artery	Human	28 days	Pure	4.0	97	Successful
2	28	M	Injury of left femoral artery	Human	28 days	Pure	3.5	..	Failure; serious infection occurred in site of operation; hence transplanted graft was removed on 27th postoperative day because of probable rupture
3	30	M	Aneurysm of left carotid artery	Human	77 days	70%	6.5	16	Failure; serious infection occurred in operated site; hence transplanted graft was removed on 16th postoperative day because of probable rupture surmised from arteriogram
4	51	F	Aneurysm of right axillary artery	Human	106 days	Pure	4.5	16	Successful
5	58	F	Aneurysm of right iliac artery	Dog	230 days	70%	4.0	12	Undecided; arteriography failed; no ascertaining of blood circulation, though clinical appearance of limb seemed normal, and no rupture could be inferred
6	10	F	Traumatic arteriovenous aneurysm of right femoral artery	Human	4 days	70%	3.4	15	Successful
7	50	M	Aneurysm of abdominal aorta	Human	18 mo.	70%	5.0	35	Successful
8	23	F	Aneurysm of right carotid artery	Dog	14 mo.	70%	2.5	..	Died of pulmonary edema on 2d postoperative day, revealed by autopsy
9	28	F	Aneurysm of right femoral artery	Dog	16 mo.	70%	6.0	25	Successful
10	62	M	Myoplastic sarcoma of left femoral artery	Dog	20 mo.	70%	11.0	16	Successful
11	53	F	Aneurysm of abdominal aorta	Sheep	5 mo.	70%	6.5	35	Successful

alcohol in three cases. In the remaining five cases, heterografts obtained from the dog and the sheep, stored in 70% alcohol, were used.

The patient in Case 2 was operated on three weeks after injury, and the patient in Case 3 underwent secondary operation; thus both patients were supposedly exposed to bacterial contamination, and pus was found at the time of operation. Consequently, in spite of abundant use of antibiotics, the operations resulted in failure. Great care should be taken to avoid infection, since such operations as insertion of a foreign body will always fail when bacterial contamination occurs. It goes without saying that the same care should be taken in the case of viable grafts.

Judging from arteriography in most cases (Cases 1, 4, 6, 7, 9, 10, and 11), the operation may be regarded as successful. In Case 5, no clinical appearance of circu-

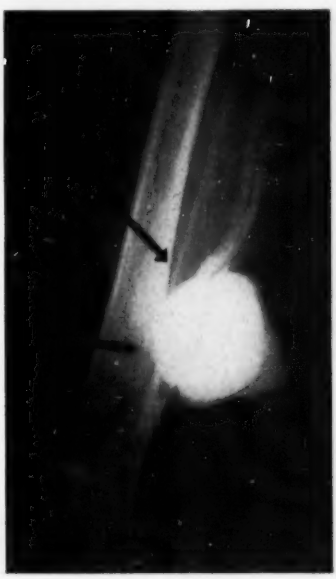

Fig. 7.—Roentgenologic visualization of the traumatic arteriovenous aneurysm of the right femoral artery in Case 6, with 20 cc. of 35% iodopyracet.

Fig. 8.—Arteriogram taken 15 days after operation in Case 6, showing the pathway of the anastomosis. This homograft had been preserved in 70% alcohol for four days before implantation.

latory disturbance of the limbs could be noticed, but the reconstruction of blood circulation could not be clearly ascertained because of unsuccessful arteriography.

In Case 8, the patient died on the third day after operation. Autopsy did not reveal any thrombus or rupture at the site of transplantation but an extensive pulmonary edema as the cause of death.

Only four cases are reported in some detail.

Case 6.—A 10-year-old schoolgirl was admitted to the hospital on July 16, 1952. At night on May 3, 1952, she fell down on fragments of broken window glass and a splinter penetrated the skin of the medial portion of her knee. Marked arterial bleeding was noted and two sutures were placed by a surgeon. The wound healed without complication, but a diffuse swelling persisted until the middle of June, 1952, when it formed a pulsating tumor.

On admission, a pulsating tumor about 6 cm. by 7 cm. in size was found in the posteromedial surface of the right thigh just above the knee joint. It seemed to be an arteriovenous aneurysm because of continuous murmur. This was confirmed by an arteriogram with 35% iodopyracet taken on June 20, 1952 (Fig. 7).

On June 25, 1953, the patient was operated on. An arteriovenous aneurysm about 6 by 7 cm. in size was removed. A homologous arterial graft, stored in 70% alcohol, of 3.4 cm. length was transplanted across the arterial defect, while the femoral vein was ligated and cut away. Postoperative course was uneventful. Arteriogram taken on July 9, 1952, showed good circulation of the femoral artery (Fig. 8).

CASE 10.—A 62-year-old man was admitted to the hospital on Jan. 17, 1953, with complaint of a hard mass in the left thigh. This tumor first appeared in January, 1947, four months after contusion of this same region.

The tumor became painful in July, 1949, and on Aug. 24, 1949, was explored by a surgeon but not removed. Pain became intolerable, bringing the patient to our hospital for relief.

Fig. 9.—Arteriogram of Case 9. The mass is lightly opacified homogeneously, indicating a vascularized tumor.

Fig. 10 (Case 9).—Tumor arising from left femoral artery was removed, and defect of 11 cm. length was bridged with an aortic graft of dog stored in 70% alcohol for 20 months. This photograph shows good circulation of the implanted artery.

Physical examination revealed a tumor about 5 by 6 cm. in size located deep in the anterior part of the left thigh. Arteriogram (Fig. 9) indicated no aneurysm, but a vascularized massive tumor was demonstrated.

On Jan. 23, 1953, operation was performed. The tumor surrounded the femoral vessels and was removed including them. The circulation of the femoral artery was reestablished with an aortic graft (taken from a dog) 11 cm. long, preserved in 70% alcohol for 20 months. Thus a heterotransplantation was performed (Fig. 10).

The removed tumor was diagnosed by the department of pathology here as myoplastic sarcoma arising from the femoral artery.

The postoperative course was quite uneventful. The pulsations of popliteal, dorsal pedal, and posterior tibial arteries were always readily palpable. The arteriogram taken on Feb. 8, 1953 (Fig. 11) showed excellent circulation of the transplanted femoral artery.

SUCCESSFUL REMOVAL OF ANEURYSM OF ABDOMINAL AORTA

Special emphasis should be made on Cases 7 and 11, because only recently a few reports have appeared on the successful removal of aneurysm of abdominal aorta (Schafer and Hardin,[33] and Dubost, Allary, and Oeconomos [34]).

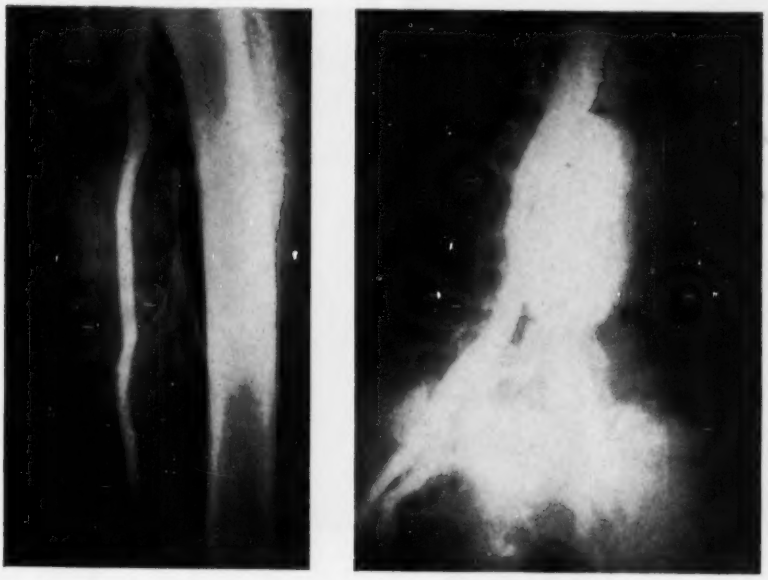

Fig. 11.—Arteriogram on the 16th postoperative day in Case 9, showing an excellent circulation of the grafted femoral artery.

Fig. 12.—Roentgenologic visualization of aneurysm of the abdominal aorta in Case 7, with 50 cc. of 70% iodopyracet.

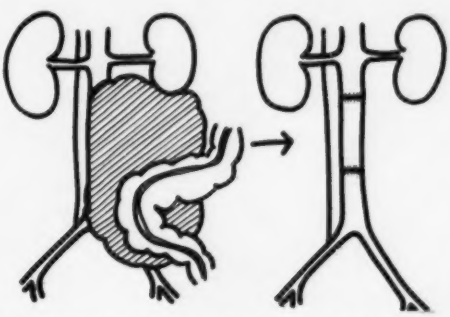

Fig. 13.—Schematized illustration of operation performed in Case 7. After the abdominal aneurysm was removed, the defect of the aorta was bridged with a human aortic graft of 5 cm. length, preserved in 70% alcohol for 13 months.

CASE 7.—A 50-year-old man, chief of a post office, had had a pulsating tumor in his left abdomen for the past 10 years. This was accompanied by such severe pain that he could walk only very slowly, had a kyphotic posture, and his sleep was frequently disturbed.

On admission, July 17, 1952, a pulsating tumor about 20 by 12 cm. in size, was found in his left abdomen. An aortogram with 70% iodopyracet is shown in Fig. 12.

On July 25, 1952, the operation was performed with the patient under spinal anesthesia. The abdominal cavity was opened, and an aneurysm of the aorta was identified. After the aorta was clamped at the proximal side of the aneurysm and then the right and left common

Fig. 14.—Aortogram taken 35 days after operation in Case 7, showing pathway of the anastomosis. This homograft had been preserved in 70% alcohol for 13 months before implantation.

Fig. 15.—Aortogram in Case 11, showing aneurysm of abdominal aorta.

Fig. 16.—Photograph of operation in Case 11. Caudal anastomosis just above the bifurcation has been completed, and the cephalad one is about to be carried out.

iliac arteries at the distal side, the aneurysmal sac was incised, and the massive thrombotic coagulant contained in it was removed. Because there was a dense adhesion between a portion of aorta and the sigmoid colon, on the one hand, and the aneurysmal sac, on the other, careful freeing was needed.

The defect of the aorta, situated about 5 cm. below the renal arteries, was bridged with a human aortic graft of 5 cm. length stored in 70% alcohol for 13 months (Fig. 13). The transplantation was completed without difficulties. The postoperative course was in general uneventful.

An aortogram taken 35 days after operation revealed an excellent pathway of aorta so that one could hardly indicate the site of the transplantation (Fig. 14). The patient was discharged from the hospital, Sept. 18, 1952, the 55th day after operation. He is well and working at the same job as before.

Case 11.—A 53-year-old housewife, was admitted to the hospital on Feb. 9, 1953, complaining of a pulsating mass about 6.5 by 4.5 cm. in size in the left abdomen since September, 1952. Pain and tenderness were absent. Aortogram revealed a diffuse spindle-like dilated aneurysm of the abdominal aorta extending from closely below the renal arteries to the bifurcation (Fig. 15).

On Feb. 18, 1953, operation was performed. Adhesions were not remarkable. The aneurysmal sac was freed, cutting several lumbar arteries of both sides, and removed, including the inferior

Fig. 17.—Aortogram of Case 11 on 35th day after operation.

mesenteric artery. The defect was bridged with an aortic graft 6.5 cm. in length (from sheep) preserved in 70% alcohol for five months (Fig. 16). The caudal anastomosis was just above the bifurcation. As the inferior mesenteric artery was cut off, the pulsation of the artery to the left colon apparently disappeared; however, since the color, temperature, and peristalsis remained normal, adequate collateral circulation seemed to be present, and so this portion of the colon was not resected.

The postoperative course was in general uneventful. An aortogram taken 35 days after operation revealed an excellent pathway of the aorta (Fig. 17). The patient returned home on the 41st postoperative day, and seven months after operation, she was quite well.

SUMMARY AND CONCLUSIONS

Satisfactory results were reported of experimental transplantation with homo- and hetero-grafts of the aorta preserved in pure and 70% alcohol at an ordinary room temperature. It is of great significance that the transplantation of heterograft

preserved in alcohol was equally successful as that of homograft preserved in a living condition, thus introducing a new simpler method of arterial transplantation.

Convinced by the laboratory experiments, we transplanted homo- and heterografts preserved in pure and 70% alcohol into 11 human subjects with results that are very promising and that merit further trial.

Among the 11 cases reported here, there are 2 patients in whom aneurysm of the abdominal aorta was removed. One of them has been followed one year and three months up to the time of completion of this paper. The result is excellent. Special attention should be paid to these two cases because grafting is absolutely necessary to remove the aortic aneurysm, and only a few cases have quite recently been reported in the literature.

At present, we prefer 70% ethyl alcohol to pure alcohol, since 70% alcohol is more effective in sterilizing grafts in storage, and since 70% alcohol grafts more quickly regain their physiological softness when immersed in salt solution.

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CARCINOMA OF AMPULLA OF VATER AND HEAD OF PANCREAS CAUSING JAUNDICE

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BECAUSE of the similarity of symptoms, diagnosis and problems of treatment, carcinoma of the ampulla of Vater and head of the pancreas near the common bile duct can be conveniently grouped together. Patients with proved tumors of this type admitted to the Veterans Administration Hospital, Hines, Ill., for the six-year period from 1945 through 1951, form the basis of this study. Primarily the purpose of the study is to evaluate methods of treatment and to correlate symptoms, signs, laboratory data, surgical findings and procedures, and survival times. Surgical technique has been presented in a recent publication by one of us (C. B. P.).[28]

In this group are 48 proved cases. Eleven patients with carcinoma of the ampulla of Vater and 37 with carcinoma of the head of the pancreas are included. Of the total number, 9 received initial care at other hospitals and subsequent care at Hines; 39 received their entire care at this hospital. Of the 47 patients known to be dead, 38 had autopsies. One patient was lost to follow-up examination after 18 months.

INCIDENCE

According to Ingelfinger [17] and others, 1 to 2% of all malignant tumors are in the region of the ampulla of Vater and head of the pancreas. At Hines, 5,765 patients with malignant tumor were admitted in the six-year period under discussion, and of these, 48 patients had proved malignant disease of the ampulla of Vater or head of the pancreas, an incidence of slightly under 1%. For no known reason, these lesions are three or more times as frequent in men as in women. Because of the preponderance of male patients eligible for veterans hospital care, there was only one female patient with carcinoma of the head of the pancreas in our series. As might be expected, the most common age group is between 40 and 70 years, but these tumors do occur at any age. The average age of all 48 patients is 57.5 years, with a variation from 24 to 73 and a 10-year graduation as follows:

Age Group	No. of Cases
20 to 29	1
30 to 39	3
40 to 49	3
50 to 59	25
60 to 69	15
70 to 79	1

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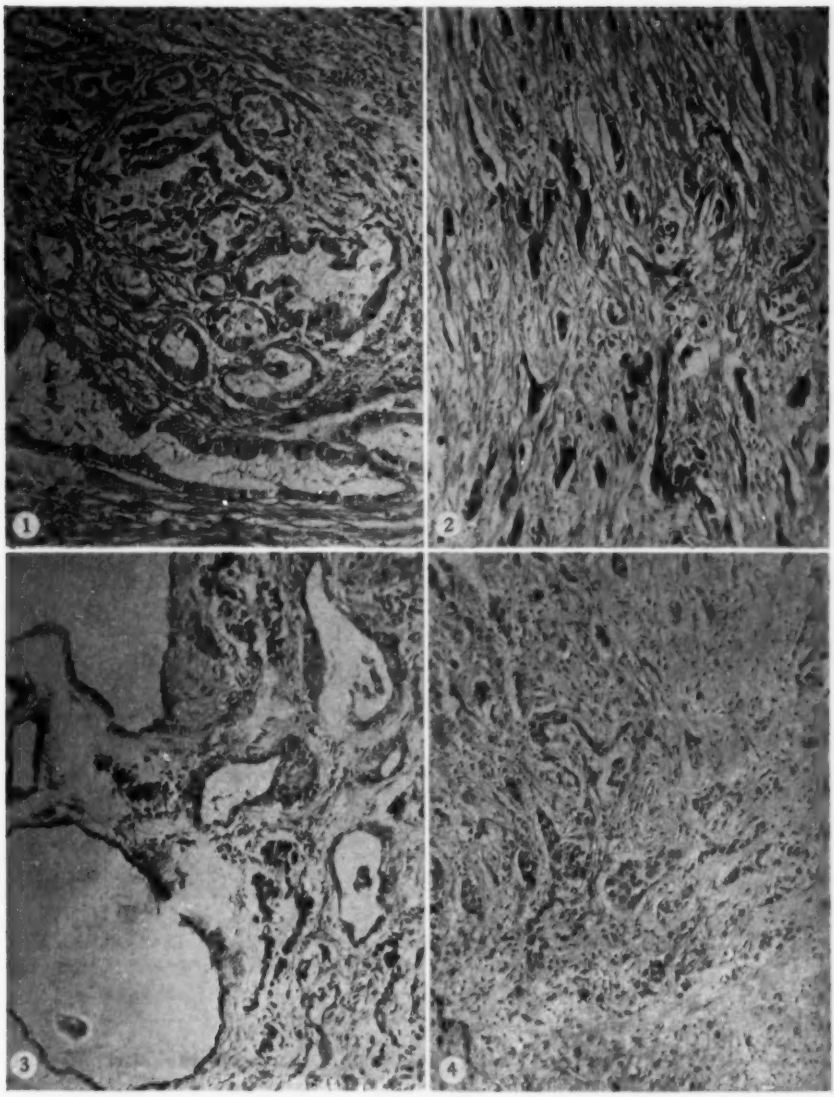

Fig. 1.—Photomicrograph of duct-cell type of adenocarcinoma of the head of the pancreas. This is the most common histological structure and is believed to originate from the pancreatic ducts. Grossly, it is hard, scirrhous, and fibrous, and microscopically has these duct-like spaces.

Fig. 2.—Photomicrograph of the occasionally observed acinus type of adenocarcinoma of the head of the pancreas. These lesions are soft and fleshy and have a medullary microscopic appearance.

Fig. 3.—Photomicrograph of the rare mucocyst-adenocarcinoma of the head of the pancreas demonstrating the large cyst-like spaces due to the presence of mucus-secreting properties.

Fig. 4.—Photomicrograph of the most commonly found type of adenocarcinoma of the ampulla of Vater which is grossly nodular, firm, white, fibrous and infiltrative with a duct-like appearance microscopically.

PATHOLOGY

Various classifications of carcinoma of the head of the pancreas have been made,* but four types are generally recognized: (1) adenocarcinomas of duct cell origin which are grossly hard, scirrhous and fibrous, and microscopically have duct-like spaces (Fig. 1); (2) acinus types which are soft and fleshy and have a medullary microscopic appearance (Fig. 2); (3) mucocystadenocarcinomas with mucus-secreting properties (Fig. 3), and (4) islet cell carcinomas. The latter two rarely are found.

Carcinomas of the ampulla of Vater usually are nodular or annular, firm, white, fibrous, and infiltrative with a duct-like appearance microscopically (Fig. 4). Occasionally, like most periampullary carcinomas, they are of a papillary type, probably

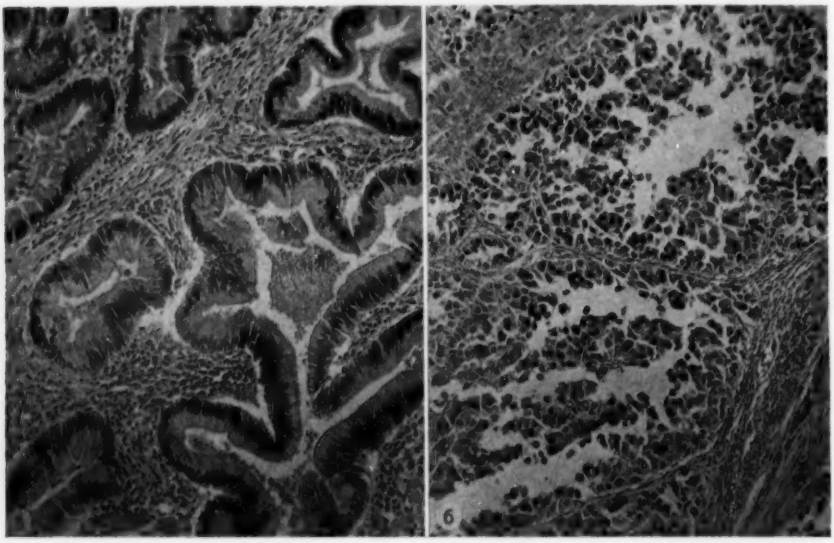

Fig. 5.—Photomicrograph of the papillary type of adenocarcinoma of the ampulla of Vater which probably originates from a villous polyp. Frozen section studies of these tumors sometimes gives the erroneous impression that they are benign, but they have a surprising tendency toward malignancy.

Fig. 6.—Rare malignant carcinoid of the ampulla of Vater.

originating from a villous polyp (Fig. 5). In this type, a frozen section may give an entirely erroneous impression of their malignant nature, as noted in a case report in this paper. Malignant carcinoid tumors may also occur in the ampullary region (Fig. 6).

Outerbridge,[27] in 1913, found metastasis in only 22% of 110 autopsied cases of carcinoma of the ampulla of Vater and stated that in 82 of these, the tumor was localized to the papilla. Other authors,† have corroborated these findings. In contrast to this, carcinoma of the pancreas metastasizes more frequently, as was shown by Mikal,[24] who found only 20 patients without metastasis in 100 proved cases of

* References 1, 8, and 13.

† References 15 and 3.

carcinoma of the pancreas. In autopsies on eight patients with carcinoma of the ampulla of Vater, he found six lesions which he considered to be surgically resectable. Therefore, it appears in many of these cases that death is not due to generalized or far-advanced carcinoma, but rather to the greatly disturbed body physiology resulting from malfunction of the hepatic, pancreatic, and digestive systems, secondary to neoplastic biliary and pancreatic obstruction. These disturbances are of prime importance in treatment as they greatly increase the operative risk. This is evidenced by Bartlett's [4] surgical mortality of 17% for exploratory laparotomy alone.

After the onset of symptoms, patients with Vaterian tumors survive much longer than patients with carcinoma of the head of the pancreas. Whipple [34] believes that this may be explained by the tendency of the ampullary lesions to grow in the lumen of the duodenum rather than into the substance of the pancreas with invasion of the lymphatics, as occurs in pancreatic head carcinoma. Furthermore, ampullary lesions, because of their proximity to the bile duct, produce specific obstructive symptoms, such as jaundice, earlier than carcinoma of the pancreas. The rate of growth of the malignant lesion may also be a factor, for Mikal [24] found that ampullary neoplasms averaged only 1 cm. in diameter compared with 5.7 cm. for pancreatic head lesions at the time of death.

DIAGNOSES

Diagnosis of neoplasms in the region of the head of the pancreas may be difficult because of anatomic inaccessibility, lack of conclusive pancreatic and hepatic function tests, and the variety of symptoms encountered.

Bockus [6] points out three predominant symptoms. First, jaundice, in 33 to 50% of ampullary carcinoma is painless and usually, though not necessarily, complete. The proximity of the tumor to the common bile duct in pancreatic head tumors determines the time of development of jaundice. It occurs much later than in ampulla of Vater lesions. The second outstanding symptom is pain, characterized in pancreatic head malignant tumors by its epigastric location with radiation through to the back. It is dull, aching, exaggerated at night, and sometimes relieved by stooping. However, occasionally in pancreatic head tumors, and commonly (50%) in ampullary tumors, pain is of a biliary colic nature. It may be associated with the occurrence of cholangitis, as demonstrated in 25 to 50% of cases at autopsy. The third and most frequent symptom is marked weight loss, almost invariably present in pancreatic carcinoma and usually present to a less degree in Vaterian carcinoma.

Other less specific and less frequent symptoms include anorexia, nausea, vomiting, diarrhea, and constipation. Pruritus may or may not be present, and sometimes antecedes the jaundice by a few days. Up to 25% of these patients may have peptic-ulcer-like pain due to malignant or concomitant benign ulceration in the duodenum. One of the later symptoms is high intestinal obstruction explained by the growth of the tumor into the duodenum.

Cataloging of all symptoms at the time of the first hospital admission demonstrated a numerical incidence as shown in Table 1.

Painless jaundice, the classic first symptom in ampullary carcinoma, was present in 9 of 11 cases, while 1 patient had peptic-ulcer-like pain with jaundice, and 1 patient's jaundice occurred two weeks after anorexia, nausea, vomiting, and chills and fever.

That pain often occurs before jaundice in pancreatic head tumors was borne out in this study of the initial symptom.

Physical examination discloses a dilated gall bladder and enlarged liver in about half of the cases ‡ on the basis of Courvoisier's Law. Conversely, 10 to 25% of patients with malignant disease of the ampullary region have cholecystitis with

TABLE 1.—*Symptoms According to Incidence*

Symptoms	Carcinoma Head of Pancreas	Ampullary Carcinoma
Total cases with good histories	37	9
Weight loss	28	5
Pain	29	1
Epigastric	15	
Back	6	
Epigastric to back	5	
Colicky pain	2	
Right upper quadrant	1	
Peptic-ulcer-like pain		1
Jaundice	29	9
Pruritus	7	4
Anorexia	12	1
Diarrhea	9	1
Nausea	11	1
Vomiting	8	1
Epigastric distress	3	1
Diabetes	6	1
Chills and fever	2	1
Constipation	3	

TABLE 2.—*Initial Symptom in Carcinoma of the Head of the Pancreas*

Symptoms	Cases
Pain	15
Epigastric	7
Epigastric to back	4
Back	4
RUQ	1
Jaundice	9
Weight loss	9
Diarrhea	6
Constipation	3
Nausea and vomiting	2
Anorexia	1
Chills and fever	1

cholelithiasis or choledocholithiasis causing inflammatory fibrosis of the gall bladder and preventing its dilation. In far-advanced cases, an epigastric mass may be present.

Physical examination revealed the frequency of abdominal findings on the 38 cases first admitted to Hines, as shown in Table 3.

Laboratory procedures which often differentiate obstructive from nonobstructive jaundice are well known and will not be discussed in detail here. They include

‡ References 5 and 21.

cephalin flocculation, serum bilirubin, serum alkaline phosphatase, total blood cholesterol, prothrombin time, serum protein levels, and other liver function tests.

Landry and Walters [19] consider blood in the stool in the presence of jaundice highly indicative of malignant disease, especially when the jaundice is present with Courvoisier's sign. It is rather impressive that in stool examinations for blood of 29 of our patients, 25 were positive and only 4 were negative. Twelve patients did not have a fecal specimen tested for blood.

As with blood in the stool, blood obtained by duodenal drainage is an important diagnostic sign. The failure of bile to enter the intestinal tract can be determined in this manner, but it is more apparent on stool examination. Cholesterol or calcium bilirubinate crystals in the material from the duodenum indicate cholelithiasis and contraindicate malignant disease. An absolute diagnosis of neoplasm can be made if tumor cells are identified in the aspirated duodenal content, as proved by Lemmon.[20]

The quantitative determination of fat and nitrogen in the stool is difficult to obtain accurately and is of value in only a small percentage of cases as an index of pancreatic function. Evidence of diabetes, as indicated by abnormal urinary and blood sugar findings, is present in a higher percentage of patients with pancreatic

TABLE 3.—*Frequency of Abdominal Findings*

	Carcinoma Head of Pancreas	Ampullary Carcinoma
No. of patients	32	6
Hepatomegaly	20	2
Enlarged gall bladder	13	2
Epigastric mass	5	

tumors than in the general population, according to Marble.[22] In our series, 15% of the patients had diabetes. Although there is a disagreement as to the diagnostic value of serum amylase and lipase determinations, the former is elevated in about half of the cases of pancreatic tumors.[5] Certainly the marked obstruction and infection associated with pancreatic tumors might well produce intermittent elevation of serum amylase and lipase levels. Serum lipase determinations showed an elevation in two of six of our cases. Serum amylase levels were elevated in 9 of 15 cases. Laboratory studies almost consistently showed evidence of the obstructive nature of the jaundice.

Watson [31] states that about 90 to 92% of the patients with neoplastic biliary obstruction excrete less than 0.3 mg. of urinary urobilinogen and 5 mg. of fecal urobilinogen daily, but in calculus obstructive jaundice, only about 7% have less than these amounts. Although our laboratory utilizes the two-hour Watson test,[32] in which below 0.3 mg. of urobilinogen per 100 cc. of urine is considered abnormal, in 24 of 27 patients with malignant biliary obstruction on whom the test was performed, the results were below normal.

When carcinoma of the head of the pancreas or ampulla of Vater is far advanced there usually is definite x-ray evidence of its presence. Unfortunately, however, in early lesions helpful x-ray findings are infrequent. As might be expected, the gall bladder usually is not visualized. Roentgenologic studies with barium meal may

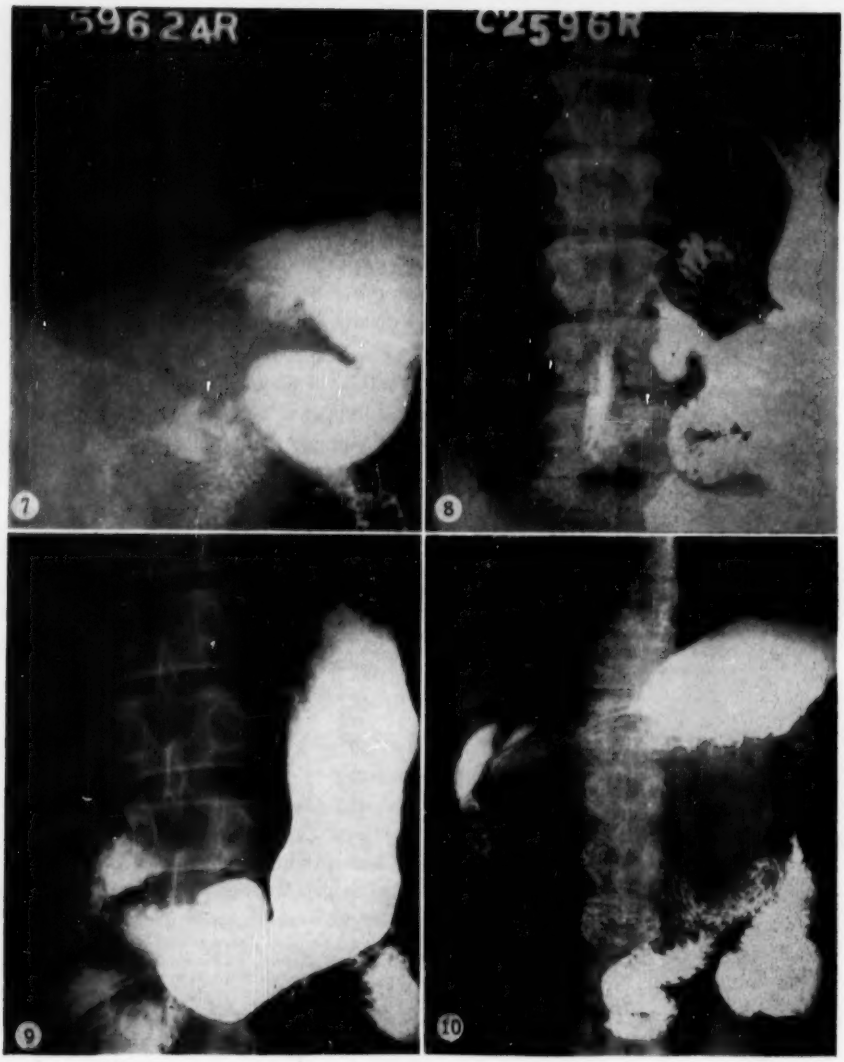

Fig. 7.—Barium meal demonstrating narrowing in the descending duodenum due to extrinsic pressure from a tumor mass in the head of the pancreas.

Fig. 8.—Roentgenogram illustrating marked enlargement of the ampulla of Vater because of malignancy.

Fig. 9.—X-ray after a barium meal showing enlargement of the papilla of Vater due to carcinoma.

Fig. 10.—An upper gastrointestinal x-ray series demonstrating the marked enlargement of the duodenal sweep that may be reached in advanced carcinoma of the pancreatic head.

visualize narrowing of the duodenum due to extrinsic pressure, persistent spasm of the descending duodenum, malignant ulceration of its second portion, or enlargement of the papilla of Vater (Figs. 8 and 9). When a pancreatic head carcinoma reaches large size, the duodenal sweep may be increased (Fig. 10). Roentgenologic studies of the upper gastrointestinal tract in the 39 patients admitted to our hospital revealed the findings shown in Table 4.

Thus, about 75% of upper digestive tract studies were not of diagnostic aid and 25% had suggested the existence of a malignant lesion in the region under discussion.

Seventeen of the patients had barium enemas; 13 were shown to be normal. One showed a sigmoid obstruction, which was found to be due to drop metastasis. Three had diverticulosis, and of these, one had diverticulitis.

DIAGNOSES AT THE OPERATING TABLE

Even at the operating table, accurate diagnosis is difficult, yet very important. Several cases have been reported in which surgical deaths have resulted when pan-

TABLE 4.—*Radiologic Findings in Thrity-Nine Cases*

	Cases	
Negative findings	29	
Normal		20
Benign ulcer in duodenal bulb		6
Positive findings	10	
Ulcer in descending duodenum		1
Widened duodenal sweep		4
Widened duodenal sweep with duodenal diverticulum		2
Widened duodenal sweep with enlarged ampulla of Vater		1
Pyloric obstruction		1
Extrinsic pressure on duodenum		1

creaticoduodenal resection was performed for benign lesions. Chronic pancreatitis can produce gross findings identical to those of a malignant condition. Hartman [14] reported that 25% of palpable pancreatic head masses were not malignant at autopsy. Walters [30] reported that in his patients with biliary obstruction due to pancreatic lesions in whom bile shunt operations were performed, 15% survived five years, suggesting that the biliary obstruction was of inflammatory origin. We agree with those surgeons who believe that before a radical pancreaticoduodenectomy is performed, a biopsy positive for malignancy must be obtained. On the other hand, deep jaundice may accompany incomplete obstruction in obscure, very small malignant lesions of the ampullary portion of the biliary tract. Landry [19] recommends that a cholangiogram at surgery or later through an indwelling T-tube may assist detection of these small tumors (Fig. 11). By this method, spasm of the sphincter of Oddi can be relaxed by the administration of amyl nitrate or glyceryl trinitrate allowing the common bile duct to empty and appear patent on the roentgenogram in contrast to persistent malignant obstruction.

In 38 of our cases, notes on the surgical findings and procedures were available, although some of the descriptions were incomplete. The findings are presented in Table 5.

Courvoisier's sign was reported present in 29 of 38 cases at operation but in only 14 on physical examination. Undoubtedly a higher incidence of common duct dilation and hepatomegaly was present than was reported. Twelve of the patients with carcinoma of the pancreatic head and two of the six patients with ampullary carcinoma had metastasis reported at the initial operation.

It is difficult to draw many conclusions from these statistics, but in the presence of jaundice with blood in duodenal aspirations or in the stool, Courvoisier's sign at surgery nearly always indicates malignant biliary obstruction.

Unless a metastatic node can be found for biopsy purposes, it may be necessary to take a biopsy specimen from the primary lesion in the head of the pancreas. This may be dangerous and uninformative. Bleeding may be troublesome and often biopsy reveals only chronic pancreatitis.[9] Sometimes persistent pancreatic fistulas or peritonitis develop because pressure in the dilated obstructed ducts is increased

Fig. 11.—A cholangiogram through an indwelling T-tube in a patient with carcinoma of the ampulla of Vater showing obstruction of the common bile duct and dilation of the biliary radicles. The pancreatic ducts are also visualized.

TABLE 5.—*Findings at Surgery*

	Carcinoma Head of Pancreas	Ampullary Carcinoma
Number of patients	31	7
Dilated gall bladder	23	6
Dilated common duct	15	6
Mass in head of pancreas	26	2
Ascites	7	1
Hepatomegaly	4	1
Metastasis	12	2

and retrograde flow through the dilated duct radicles in the biopsy incision may occur. Perhaps biopsy with a Vim-Silverman needle as recommended by Kirkland [18] may be a solution of this problem.

The value of searching for metastatic nodes for biopsy is indicated in Table 6, which shows that 11 of 13 metastatic node biopsies established a positive diagnosis.

On the other hand, five biopsy specimens of the primary lesion, later proved to be carcinoma, were diagnosed as chronic pancreatitis and only two were stated to contain tumor. In ampullary tumors, five of seven biopsy specimens of the primary tumor were positive.

Because of the great difference in prognosis as well as treatment, differentiation of pancreatic head carcinomas from ampullary carcinomas is important at surgery. In all 7 of the Vaterian tumors, but in only 3 of the 31 pancreatic tumors, did transduodenal explorations indicate an accurate degree of differentiation.

After reviewing a number of articles in the literature, it appears to us that a few hints systematically followed at the operating table may facilitate diagnosis:

1. Complete and careful preoperative review of the clinical and laboratory findings should be correlated with surgical observation.

2. A distended gall bladder and common duct usually indicates malignant obstruction at or near the ampulla.

3. Observation and palpation and biopsy of metastasis may establish the diagnosis and dictate the surgical procedure.

TABLE 6.—*Results of Biopsy*

		Primary Lesion Biopsy		Metastatic Biopsy	
	Cases	Positive	Negative	Positive	Negative
Pancreatic carcinoma	28	2	5	11	2
Ampullary carcinoma	7	5	2	1	0

4. Next, palpation of head of the pancreas may demonstrate a mass. Biopsy of this may be performed with a Vim-Silverman needle.

5. The common duct and ampulla are then carefully palpated and explored, the latter transduodenally. Biopsy of ampullary lesions is recommended.

6. In the presence of jaundice and a dilated biliary system without demonstrable cause, a T-tube in the common duct may permit pancreatitis to subside and will permit cholangiograms as described above.

TREATMENT

Despite the hopes generated by pancreaticoduodenal resection, the problem of curative treatment in most cases of carcinoma of the head of the pancreas remains unsolved. Whipple [34] reported that untreated patients with pancreatic head neoplasms survive an average of six months. Bartlett [4] reported an average survival of only two months after exploratory laparotomies, 5 to 9 months after palliative operations, and 7 to 11 months after pancreaticoduodenal resection. Only four patients with pancreatic carcinoma have been reported to have lived more than five years [26] after operation, although a number of survivals of such patients with ampullary tumors have been reported. Probably because of earlier symptoms, slower growth and a lower grade of malignancy, survival time of patients with ampullary tumors is much longer. Hunt [16] reported that 60% of his large group with ampullary tumors who survived surgery lived more than one year.

As was previously stated, the marked physiologic malfunction produced by neoplastic biliary obstruction results in such delicate balance between life and death that even a slight surgical insult may tip the balance the wrong way. This is borne out by these figures of operative mortality from several sources.§

Explorative laparotomy	17%
Palliative procedures	20 to 25%
Pancreaticoduodenal resection	14 to 50%
Local excision of ampullary tumors	29%

Recent scientific progress has materially reduced surgical mortality and complications. The appalling mortality rate due to hemorrhage which led Hunt to write, "It is more probable that the cause of death in 50 percent of the cases was hemorrhage," has largely been remedied by the use of blood transfusion and vitamin K. Likewise, better surgical technique, less infection, pancreatic anastomosis into the intestinal tract, and less hemorrhage have diminished the frequency of troublesome fistulas. Antibiotics and the previously mentioned factors have reduced the formerly high incidence of bacterial and chemical peritonitis and perihepatic abscesses.

Although better preoperative and postoperative care have decreased the incidence of hepatorenal failure, it still presents an extremely difficult complication for which we have no specific treatment.

PALLIATIVE SURGERY

In pancreatic head carcinoma, such an authority on pancreaticoduodenal resection as Whipple has said that results with radical surgery are most discouraging. Cattell [10] has recommended that all of these patients should undergo palliative surgery. In addition to most pancreatic tumors, far-advanced ampullary lesions should also be treated by palliative operations. Of first palliative importance is the relief of the jaundice to permit some restoration of normal physiology and thereby alleviation of the agonizing pruritus. The bile stream preferably should be returned to the intestinal tract, but with the high surgical mortality for simple procedures, the least traumatic operation possible may be indicated. Sallick's [20] external biliary drainage (cholecystostomy), with a mortality of 11% at a time when internal biliary drainage had a surgical death rate of at least 33%, is rather impressive for critically ill patients. Some surgeons recommend that the bile should be fed back to the patient.

For anastomosing the biliary tract to the digestive system, the gall bladder is the organ of choice because of its ready availability and ease of anastomotic technique. Cholecystogastrostomy is criticized by some authors because of the possibility of gastric contents being forced into the gall bladder by stomach contractions, thus causing ascending cholangitis, because of resultant stricturing of the stoma, and because the stomach does not well tolerate large amounts of bile.[34] Other writers report that they have not seen bad results from cholecystogastrostomy.[2]

An antecolic cholecystojejunostomy by a Roux-Y limb, jejunal loop, or a loop with a lower enteroenterostomy theoretically avoids the criticisms of a shunt into the stomach and is successful in practice.[10] Cholecystoduodenostomy may be contraindicated because of the proximity of the tumor to the stoma and the possibility of obstruction by extension of the malignant lesion.

§ References 4, 7, 16 and 25.

In the absence of the gall bladder or fibrosis of it or the cystic duct, the common bile duct may be anastomosed to the intestinal tract. This requires more dissection and presents more technical difficulties.

Malignant disease of the head of the pancreas or ampulla of Vater may produce death due to intestinal obstruction from ingrowth of tumor into the duodenum. Gastroenterostomy should be performed for impending or existing duodenal obstruction. Cattell has reported a palliative procedure in which he anastomosed the dilated pancreatic duct to the jejunum. No further reports on this have appeared in the literature.

PALLIATIVE SURGICAL TREATMENT AT HINES

Fairly complete data is available on the type of surgery and results in all cases in this study. Because of the great pathological variation, the 37 patients with pancreatic head tumors will be separated from the 11 with ampullary lesions. All of the patients with pancreatic tumors who were operated upon had palliative operations. These are summarized in Table 7.

TABLE 7.—*Pancreatic Head Neoplasms, Thirty-Seven Cases*

	Cases	Operative Deaths	Survival After Onset of Symptoms, Days	Survival After Surgery, Days
Not operated on because of advanced tumor or refused	4	0	159	...
Exploratory operations	3	0	161	33
Cholecystogastrostomies	14	3 (21%)	317*	178*
Cholecystojejunostomies	6	2 (33%)	241*	165*
Cholecystojejunostomies with Roux-Y or enteroenterostomies	3	0	402	266
Choledochogastrostomy	1	0	500	309
Choledochoduodenostomy	3	0	579	248
Cholecystoduodenostomy	1	0	1,616	75
Cholecystotomy	1	0	97	32
Cecostomy	1	1 (100%)	140	7
Gastroenterostomies (with other procedures)	4	(Included in above figures)		

* Not including operative deaths.

Six operative deaths (18%) occurred in the 33 patients operated on. If the three patients on whom exploratory procedures were performed are excluded, the surgical mortality rate for palliative operations is 20%.

The tabulated reasons for these deaths follow:

Advanced tumor	2
Pneumonia	1
Bleeding malignant ulcer	1
Hepatorenal failure	1
Cause not definite	1

An attempt was made to evaluate the comparative amount of relief of symptoms which these patients with carcinoma of the head of the pancreas received from different palliative operations, but uniformly the results were only fair. Pain either developed or continued and became more intense. Poor appetite, nausea, vomiting, and weight loss persisted. Jaundice was temporarily relieved, but often recurred.

The specific cause of death in these far-advanced tumor cases was often hard to determine, even when an autopsy was performed. Grouping of the causes of death of the 31 patients who survived surgery according to the palliative operations performed lends a little information, as shown in Table 8.

One patient was not operated on, and one upon whom a cholecystojejunostomy with a Roux-Y limb was performed died of cholangitis. In our series, cholangitis caused death less frequently following cholecystogastrostomy than after anastomosis of the gall bladder to the small bowel.

CURATIVE SURGERY

Earlier in this discussion, the discouraging results of pancreaticoduodenal resection for carcinoma of the head of the pancreas have been presented. In view of these results, we believe that such a radical operation with its high surgical mortality should be performed only on patients with small carcinomas of the head of the pancreas proved by biopsy and without evidence of local or distant metastases. However, in neoplasms of the ampulla, two potentially curative operations, radical pancreaticoduodenal resection and transduodenal local excision, are available but have not yet been adequately compared for evaluation.

TABLE 8.—*Cause of Death in Pancreatic Head Tumors—Thirty-One Cases Excluding Operative Deaths*

	Cases	Advanced Tumor	Hepatic Abscess Cholangitis	Hemorrhage from Ulcer	Cause Undetermined
Not operated on	4	2	1	..	1
Exploratory operation	3	3	..	..	..
Cholecystogastrostomy	11	9	2 (18%)	..	..
Cholecystojejunostomy	4	2	1 (25%)	1	..
Cholecystojejunostomy with Roux-Y or entero-enterostomy	3	1	1 (33%)	1	..
Choledochogastrostomy	1	..	..	..	1
Choledochoduodenostomy	3	2	..	1	..
Cholecystotomy	1	1	..	..	..
Cholecystoduodenostomy	1	1	..	..	..

Although Cattell reported only 1 surgical death in 22 cases of pancreaticoduodenectomy for carcinoma of the ampulla of Vater, most surgeons have had an operative mortality from 17 to 50%. Because of the high operative mortality, we believe that pancreaticoduodenal resection is contraindicated in the absence of a positive biopsy, in the presence of metastasis, and with local extension of the tumor beyond the line of resection.

In severely ill patients with jaundice of several weeks' duration or marked hepatomegaly, a two-stage radical pancreaticoduodenal resection in which the first stage consists of a cholecystojejunostomy usually is indicated. This is followed by a rapid improvement in the patient's general physiological state due to improved bile drainage and permits the second stage to be carried out more safely a few weeks later. Another advantage is that a less skilled surgeon may do the primary stage when he unexpectedly finds the necessity for it and may then refer the patient for the more difficult second stage. The two-stage procedure has been unwisely criticized because of adhesions forming between stages and because of two anesthetics and two operations. However, for some patients it appears to be a much safer technique.

Whether the remaining tail of the pancreas should be anastomosed to the digestive tract, or whether the pancreatic ducts should be ligated and the cut end over-

sewn is controversial. Better postoperative digestion and lessened incidence of fistulas have been reported [25] with reanastomosis. A picture of a specimen from a pancreaticoduodenal resection is presented in Figure 12*A* and *B*.

Transduodenal local excision of ampullary lesions is a less formidable procedure than the radical operation, but the surgical mortality is high. Hunt reported a 29%

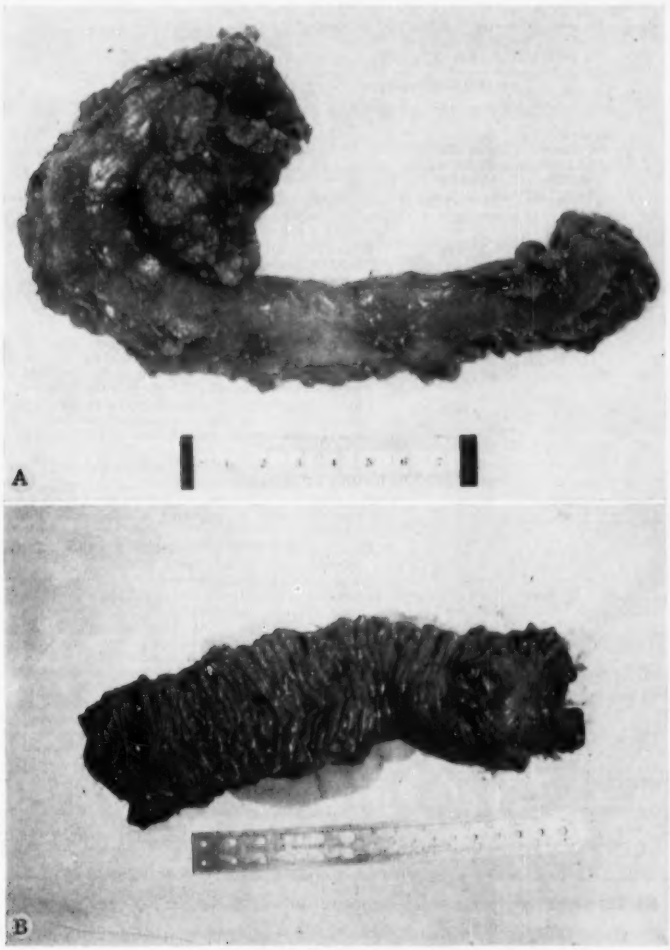

Fig. 12.—*A*, Anterior view of gross surgical specimen from pancreaticoduodenectomy for carcinoma of the ampulla of Vater showing the head of the pancreas and the duodenum. *B*, View of the opened specimen from the same pancreaticoduodenectomy showing the carcinoma of the ampulla of Vater.

operative death rate in 1941. Some impressive results have been reported with a number of five-year cures. If on transduodenal inspection it appears that a local excision will remove all of the tumor, and especially if on microscopic examination of the specimen no invasion of the duodenal wall has occurred, the less formidable

operation could be indicated.[36] Certainly, if invasion beyond the line of excision has occurred on gross or histologic examination of the removed specimen, pancreaticoduodenectomy may be performed immediately or delayed until the patient has responded to improved biliary drainage.

In addition to the above-mentioned objections to local excision, the possibility of retrograde cholangitis after loss of the valve action of the sphincter of Oddi has been suggested.

TABLE 9.—*Results of Surgery in Eleven Cases*

Patients	Survival After Onset of Symptoms, Months	Survival After First Surgery, Months	Operation, Result, Cause of Death
T. O.	At least 18	At least 18	Exploratory with persistent intermittent biliary fistula and jaundice; six mo. later repeat exploratory with same results; well when lost to follow-up 18 mo. later
M. C.	2½	8 days	Cholecystogastrostomy; died 8th postoperative day; hepatorenal failure
G. M.	21	17	Cholecystojejunostomy; good for 13 mo., then vomiting, jaundice, fever; vomiting relieved by gastroenterostomy; died of cholangitis, malignant duodenal ulcer and liver metastasis
W. M.	43½	41	Side-to-side choledochoduodenostomy; well for 20 mo. then chills, fever, jaundice, relieved by choledochoduodenostomy; well for 6 mo. then vomiting relieved by gastroenterostomy; died; advanced tumor
R. S.	35½	34½	Choledochoduodenostomy; well for 10 mo., then jaundice relieved by pancreaticoduodenectomy; well for 8 mo., then pain, weight loss, anorexia; died of advanced tumor
O. C.	22	20	Pancreaticoduodenectomy; well for 1 yr., then pain; died of advanced tumor
S.	2½	1	Pancreaticoduodenectomy; biliary fistula; died 32d postoperative day of repeated hematemesis from splenic artery perforation
F. W.	31	30	Local excision of tumor; well 18 mo., then jaundice and anemia; died of advanced tumor
P. D.	19½	18	Local excision of tumor; well 13 mo., then jaundice not relieved by cholecystotomy; died with local recurrence, liver necrosis, duodenal gastric ulcers
A. L.	142	136	1939 cholecystotomy; no improvement, then local excision of tumor; well until 1943—two bouts cholangitis; well until 1948 then jaundice; no relief after cholecystogastrostomy; relieved by choledochoduodenostomy; 1950 died of heart disease
E. B.	96	15½	Jaundice for 7 yr., thought to be due to hepatitis, then local excision of ampullary tumor diagnosed as benign lesion; improved for 5 mo., then increased jaundice; exploratory demonstrated carcinomatosis

SURGERY IN MALIGNANT AMPULLARY TUMOR CASES AT HINES

The 11 patients with Vaterian tumors had 21 operations. Of these, four had both palliative and curative procedures, making analysis a little confusing. Consequently, all 11 cases are presented in some detail in Table 9.

Despite the multiplicity of surgery, these patients could be divided into three groups, which are presented in Table 10.

The palliative operations for carcinoma of the ampulla of Vater resulted in a surgical mortality of 25% (1 death) due to hepatorenal failure on the eighth postoperative day. The three patients surviving surgery lived an average of over two years after the onset of their symptoms, and just under two years after their first operation. They lived comfortably for most of this time.

Unfortunately, the two types of curative operations cannot be adequately compared in this series. Of the three patients who had pancreaticoduodenectomy, one

had a side-to-side choledochoduodenostomy initially followed in 10 months by a recurrence of his symptoms, at which time a pancreaticoduodenectomy was performed. Perhaps if the latter operation had been done initially, the patient would not have died of advanced tumor 35½ months after the onset of his symptoms. Of the remaining two, one died on the 32d postoperative day of hematemesis from perforation of the splenic artery into the stomach, a surgical mortality of 33%. The other patient lived 22 months after the onset of his symptoms.

Four patients had transduodenal local excision of ampullary tumors with no surgical mortality. Two of these cases are especially noteworthy.

REPORT OF CASES

CASE 1.—Mr. E. B., a 30-year-old butcher, had intermittent painless jaundice for two years diagnosed as virus hepatitis followed for five years by mild continuous jaundice, during which time he felt well and worked. Finally, he was admitted to the hospital because of pain in the right upper quadrant. At operation a large papilloma of the ampulla of Vater was resected transduodenally. It was diagnosed by frozen and fixed microscopic section as "benign papilloma." Because of increasing jaundice after five months an exploratory laparotomy was performed, which revealed generalized abdominal carcinomatosis. As was previously mentioned, papillomas

TABLE 10.—*Surgical Mortality in Series*

	Patients	Surgical Mortality, Per Cent	Survival After Onset of Symptoms, Months	Survival After First Surgery, Months
Palliative operations	4	25	27+*	21½
Pancreaticoduodenectomy	3	33	28½	27
Local excision of ampullary tumor	4	0	72	51

* One patient lost to follow-up after 18 months.

of the ampulla of Vater, in our experience, may not appear histologically to be malignant, but clinically are so and must be treated accordingly.

CASE 2.—Mr. A. L., a 58-year-old school teacher, is the only patient in this series who can be considered to have been cured of cancer. He survived 12 years after the onset of his symptoms and 11½ years after the transduodenal local excision of his carcinoma of the ampulla of Vater and died of heart disease.

SUMMARY AND CONCLUSIONS

Thirty-seven proved cases of carcinoma of the head of the pancreas and 11 proved cases of carcinoma of the ampulla of Vater occurring at the Veterans Administration Hospital, Hines, Ill., from 1946 to 1951 inclusive, were analyzed to evaluate methods of diagnosis and treatment.

The average age of these 48 patients was 57.7 years. The patients with carcinomas of the pancreatic head survived an average of 10.5 months after the onset of their symptoms, and 4.8 months after surgery. Those with carcinoma of the ampulla survived an average of 39.2 months after their symptoms began, and 30.2 months after surgery.

The triad of symptoms, first pain, followed by jaundice and weight loss, are important in malignant tumors of the pancreatic head. Painless jaundice and weight loss are important in Vaterian carcinoma.

Blood in the stool or in duodenal contents with jaundice is highly indicative of malignant biliary obstruction. Clinical laboratory studies show an obstructive

type of jaundice. X-ray studies are helpful when showing positive findings. Urinary urobilinogen determinations below 0.3 mg. per 100 cc. of urine were usually present.

Correlation of operative findings of Courvoisier's sign with preoperative findings is diagnostically of great aid. Biopsies of metastatic lesions give accurate histologic information. In most patients it is difficult to obtain satisfactory biopsy specimens from primary carcinomas of the head of the pancreas, but they are essential to the determination of the treatment employed. Biopsies of lesions of the ampulla of Vater should always be performed.

Palliative bile-shunting operations can be recommended for most pancreatic head tumors and for advanced Vaterian carcinoma. It appears to make little difference whether the gall bladder is anastomosed to the stomach or to the small bowel.

Pancreaticoduodenal resection may be performed in the small pancreatic head carcinoma proved by biopsy without local or distant metastasis,

Early cases of ampullary carcinoma may be treated with local transduodenal excision. If all of the ampullary tumor cannot be removed by local excision, radical pancreaticoduodenal resection is indicated. In poor-risk patients this may be performed in two stages.

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EXPERIENCES WITH RECONSTRUCTIVE SURGERY OF FEMORAL ARTERY IN ARTERIOSCLEROSIS OBLITERANS

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ALTHOUGH successful surgical reconstruction of injured arteries was not infrequently reported for many decades before World War II,* such results could in those years by no means be uniformly predicted. That operations on arterial and arteriovenous aneurysms could be expected to be followed by continuity of the artery in a majority of cases was not demonstrated until the publication of the work on the casualties resulting from that war.[5] The experience of the later part of the Korean campaign with its fixed battle line allowing specialized surgical personnel access to the injured shortly after wounding marked one more important step forward by demonstrating that the majority of acute injuries to major vessels could also be successfully repaired.[6]

The concept of reconstruction of arteries whose functional continuity has been impaired as a result of arteriosclerosis is of more recent origin. The original impetus to perform such operations was imparted by Dos Santos [7] and quickly taken up and modified by Reboul and Bazy,[8] who performed thromboendarterectomy, a procedure which removes the organized thrombus, the arteriosclerotic intima, and half the media as a single sequestrated core. Arteriograms taken after the procedures showed that about 50% of the reconstructions had remained open.

Although grafts to replace diseased arteries had been used earlier after removal of aneurysms,[9] the first reports of the insertion of grafts to replace or by-pass obstructed segments came from Kunlin, in 1949,[10] who found that the foot pulses distal to the reconstructions became palpable in 8 of the 11 cases in which he used autogenous saphenous veins for grafts. The work of Julian,[11] who reported 18 cases with only 6 failures of patency, has been outstanding, and Rob, in England,[12] has made a significant contribution by employing homologous arterial grafts perserved in a manner modified after the method of Gross and his associates.[13]

MATERIAL

During the 12 months beginning on Nov. 1, 1952, there were 29 limbs demonstrating ischemic symptoms subjected to arteriography or aortography on the First Surgical Division of the Boston Veterans Administration Hospital (Table 1). In

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* References 1 to 4.

8 instances the site of occlusion was in the iliac artery only; in 19, in the femoral artery only, and in 2, in both arteries. Of the 19 limbs demonstrating occlusion in the femoral artery only, 10 (involving 9 patients) have been subjected to reconstructive surgery and are here reported. In seven of the remaining nine limbs the popliteal artery was visualized so that a reconstructive operation would have been anatomically possible had not it been vetoed or postponed in five because of the poor condition of the patients and in two because the patient did not wish surgery. In two cases only was the popliteal artery not visualized by arteriography (Table 2). This incidence of potentially operable lesions is higher than others reported.†

Indications for arteriography were tissue necrosis and/or intermittent claudication in a limb in which a popliteal pulse was not palpable, provided the patient could be considered a reasonable operative risk. There were a few patients in the poor-risk group who had clinical findings indicating an anatomical set-up favorable

TABLE 1.—*Site of Arterial Obliteration in Twenty-Nine Arteriograms*

Iliac only	8
Iliac and femoral	2
Femoral only	19
Total	29

TABLE 2.—*Treatment of Nineteen Obliterations of the Femoral Artery*

Reconstructive operation		10
No reconstructive operation		9
Complicating factors present	(5)	
Patients refused	(2)	
No main distal artery visualized	(2)	

to reconstruction but in whom arteriography was not performed. The exact number of this type of patient coming under our care has not been recorded.

Of the 10 extremities subjected to operation, 7 were afflicted with intermittent claudication, 2 with rest pain and intermittent claudication, and 1 with tissue necrosis of the tips of the toes.

Complicating features in the nine patients were an old hemiparesis in one, a previous coronary occlusion in one, a loss of the other limb due to arteriosclerosis obliterans in one, and a mild arterial hypertension (diastolic over 90, systolic over 140 mm. Hg) in all. Only two of the nine patients demonstrated evidence of diabetes mellitus.

INDICATIONS FOR OPERATION

The most important current problem relating to this type of surgery is to decide on the exact indications for its performance. To date there has been disagreement as to whether all patients with intermittent claudication who are reasonable operative risks or merely those who are severely disabled by their ischemic symptoms should be subjected to reconstructive operations. Since the answer to this question cannot

† References 13 and 14.

TABLE 3.—*Ten Cases of Reconstructive Surgery for Arteriosclerotic Occlusion of Femoral Artery*

Case	Date of Operation	Length of Reconstruction, Cm.	Type of Graft	By-Passed Artery Resected	Thromboendarterectomy Added	Early Reoperation	Early Postoperative Arteriogram	Later Postoperative Arteriogram	Preoperative Symptoms	Postoperative Symptoms	Length of Follow-Up, Mo.	Pulses Below Reconstruction	
												Early	Late
A. P.	2/10/53	25	Homologous artery	+	0	0	0	Not done	Intermittent claudication	Same	12	0	0
J. L.	3/ 4/53	14	Homologous artery	+	0	0	+ 2 mo.	Not done	Necrosis	None	8	+	+
J. P.	5/20/53	13	Autogenous saphenous vein	+	0	0	+ 3 wk.	0 (8 wk.)	Intermittent claudication	Improved, but patient less active	6	+	0
F. B.	5/25/53	20	Autogenous femoral vein	+	0	0	+ 2½ wk.	0 (10 wk.)	Intermittent claudication, rest pain	Improved slightly	6	+	0
C. G. R. (right)	6/22/53	18.5	Autogenous saphenous vein	0	+	+	Not done	+ 6 mo.	Intermittent claudication	None	5	+	+
C. G. R. (left)	8/ 7/53	25	Autogenous saphenous vein	0	+	+	+ 13 days	+ 7 mo.	Intermittent claudication	Same	3	+	0*
C. R.	9/ 3/53	19	Homologous artery	0	0	0	+ 8 days	Not done	Intermittent claudication & acute occlusion	None	2	+	0
J. H.	9/22/53	15	Autogenous saphenous vein	0	+	0	+ 6 wk.	Not done	Intermittent claudication	None	4	+	+
R. A.	9/30/53	12	Autogenous saphenous vein	0	0	0	+	Not done	Intermittent claudication	None	3	+	0
H. M. (right)	10/26/53	25	Autogenous saphenous vein	0	+	0	Not done	Not done	Intermittent claudication	None	2½	+	0

* Later occlusion in iliac artery above graft (three months after operation).

be given until enough time has passed to tell us how long the grafted arteries will stay patent, however, it behooves us for the present to concentrate on practical matters of surgical management. Indications will, in the end, depend on the successful performance of the reconstruction with its implications as to lack of mortality or morbidity and permanence of patency. Table 3 presents a composite of the cases here reported.

PRACTICAL CONSIDERATIONS

Selection of the Type of Graft.—Seven autogenous veins and three homologous arteries were used in the 10 cases. Of the seven veins, one was femoral; the other six, saphenous. Partly because of the fact that autogenous tissue will survive where homologous will not, but largely because of the difficulty of procuring long arterial grafts of the dimensions necessary to replace or by-pass long segments of inadequate femoral artery, the saphenous vein has been used by choice. There are occasions, however, usually unpredictable, when, because of small size or dilatation, the saphenous vein may be inadequate. It is because of such cases that it is well, if possible, to have access to a "bank" of stored arteries. As third choice, autogenous superficial femoral veins may be used, but they are low on the list because of the disparity in size between the femoral vein and artery and the potential of edema resulting from interference with the venous return. If venous thrombosis does not occur, as it did not in our case, however, little disability will result from simple removal of a segment of superficial femoral vein. Homologous saphenous veins removed by stripping [15] have not been used by us. It is of interest that in three of the four unsatisfactory results in the 10 operations reported all three types of graft were represented, namely, homologous artery, autogenous saphenous vein, and autogenous femoral vein. Technical matters, rather than the type of graft, appear to us to have been responsible for the failures.

Preparation of Patient.—An attempt should be made prior to the operation to delineate the course of the saphenous vein between Scarpa's triangle and the knee joint. In most of the cases it can be outlined by percussion of the fluid wave which is demonstrable in the contained blood of most saphenous veins, even when nonvaricose, if the patient has been allowed to stand for five minutes or more in the upright position. Skin scratches are made in order to have a landmark for the operative incision.

Two types of position on the operating table are possible: the lateral position, similar to the Sims, and the supine position (Fig. 1). The lateral position is used when the block is low and it is certain that the popliteal artery must be handled in its lowermost portion. In these patients, arteriography usually will show that the femoral artery can be used for anastomosis considerably below its bifurcation, but if this is not the case the operation must perforce be done in the supine position in order to allow access to the upper femoral artery. In this instance, popliteal anastomosis can be done by "frogging" the leg even though it is considerably more difficult thus to expose the lower popliteal artery than if the patient is in the lateral position. In the 10 operations the lateral position was used twice only.

The incision is made 1 cm. away from the course of the saphenous vein, so that when it is dissected from the flap too widely a strip of skin between the site of the

vein and the operative incision will not be left for possible ischemic necrosis. If a homologous "bank" artery is to be used, the considerations mentioned above, which apply to using the saphenous vein as a graft, should be omitted. The incision is then made in two parts, an upper and a lower, over the points where arteriography shows that the anatomosis will be most likely to be optimal and the graft tunnelled through the femoral sheath between them. For the purposes of this description, however, the use of the saphenous vein and the single incision is assumed.

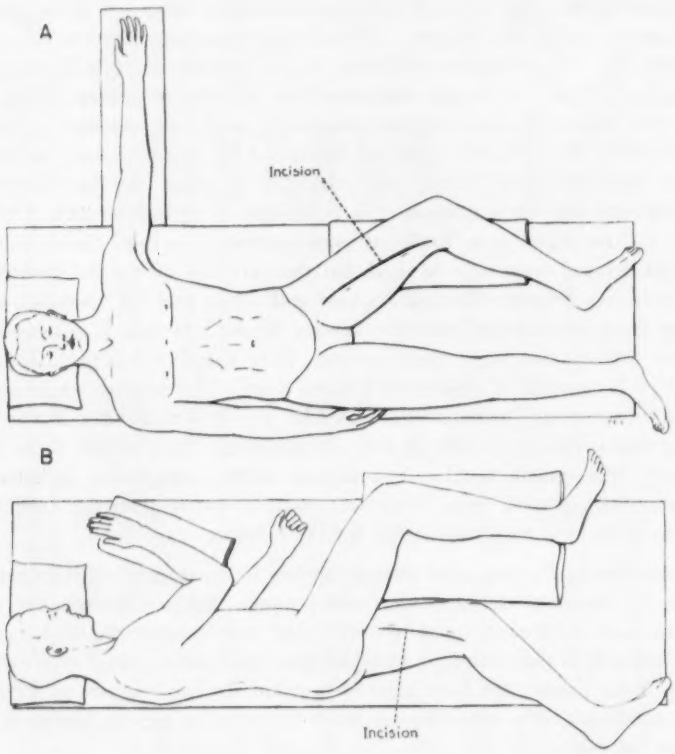

Fig. 1.—The two positions used for operative incision: (*a*) supine position; (*b*) lateral or Sims position.

Order of Procedure.—The incision need not be made deeper than through the level of the superficial fascia except at those points where the upper and lower artery are to be exposed. The lower artery is dissected first, since the adequacy of that segment has generally been more doubtful by arteriography, and its examination at this point will decide whether the operation may be proceeded with. It is freed up for 2 or 3 cm. of its length, any necessary collaterals being divided, and a likely spot for anastomosis decided upon by palpating for the softest point in the artery.

A similar procedure is then performed on the upper artery, a tentative site for anastomosis being selected as determined by softness of the artery and the force of the pulsation.

If all looks favorable for reconstruction, a suitable length of the saphenous vein is then dissected out but is left attached at both ends, the upper to the femoral vein and the lower to the veins returning from the calf at about the level of the knee joint. Branches are ligated and divided 2 to 3 mm. away from the parent vein (Fig. 2).

Attention is then turned to the lower artery which is divided at the point previously selected, the vigor of bleeding from both cut ends being determined and recorded prior to ligation of the proximal segment and application of a bulldog clamp to the lower segment. After the upper end is ligated, the lower end is inspected to see whether it has been divided at the optimum point for an anastomosis. It may be discovered that further cutting back and further division of collaterals is necessary in order to acquire the best possible lumen for anastomosis or to attain adequate mobility in order to have room to insert the sutures. A thromboendarterectomy is usually unnecessary in the lower end but may of necessity be required

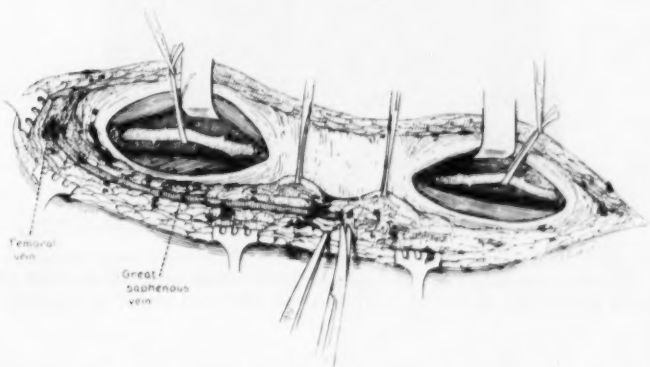

Fig. 2.—Initial exposure of femoral and popliteal arteries, preparation of saphenous vein.

occasionally when no soft pliable spot can be selected. If it is done, the cut edge of the intima which is left should be sewn to the remaining media and adventitia in order to avoid dissection of the arterial stream beneath it which will elevate a flap of intima and obstruct the lumen (Fig. 3). Attention must be given at all times to careful intimal toilet. Irregularities may occur due to intrusion into the lumen of the main vessel by the core of an arteriosclerotic collateral which has been cut by a ligature. This should be carefully removed.

The lower artery being thus properly prepared, the saphenous vein is divided above at its junction with the femoral and below in the lowermost portion of the wound. Its position in the wound is reversed (Fig. 4). It is thoroughly irrigated with isotonic sodium chloride solution and anastomosed to the open end of the distal or popliteal artery. In these patients, everting mattress sutures have been used, but over-and-over sutures are equally good, provided approximation of the intimas of the two vessels can be procured.

The upper artery is then divided, selecting the proper spot in a fashion similar to the lower artery. Here thromboendarterectomy is more often necessary and

may be frequently advisable in a case of doubt. The chief indication for it is the situation in which the cut end of the upper artery is so rigid that it will not evert for a proper anastomosis. Under these circumstances anastomosis of the vein to it may result in its being pulled into the lumen of the artery and causing an area of constriction (Fig. 5).

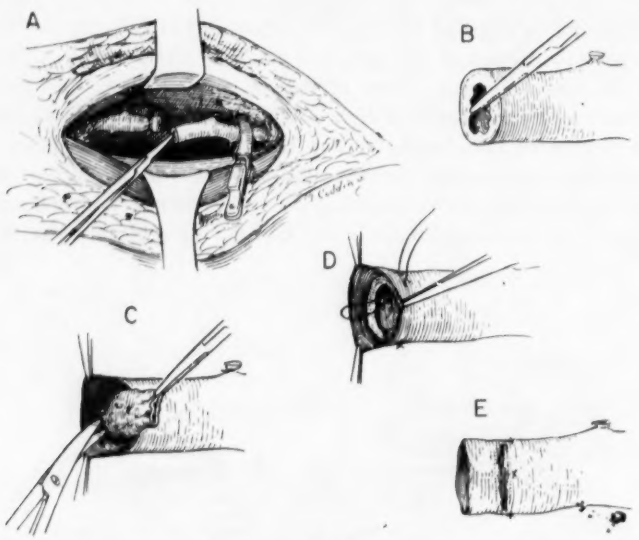

Fig. 3.—Thromboendarterectomy of popliteal artery, demonstrating necessity of suturing edge of divided intimal cuff to wall of artery to avoid subintimal dissecting hematoma.

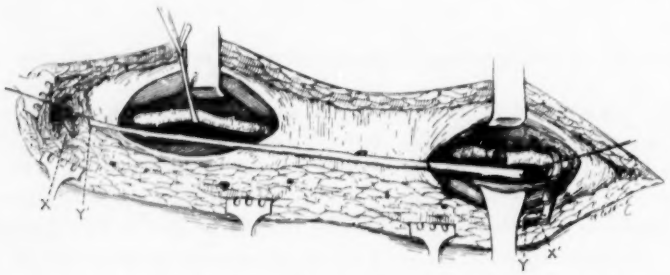

Fig. 4.—Completed preparation and reversal of saphenous vein.

When the final site for an anastomosis in the upper artery has been decided upon and prepared, the saphenous vein is tunneled through the deep vascular channel in the thigh, passing, however, medial to the adductor magnus and being careful to avoid torsion. After excess vein from the upper end has been cut away, it is anastomosed to the upper or femoral artery. Before the anastomosis is started, saline is irrigated through, not only in order to wash away any fibrin which may have accumulated in the graft but also to test the lower anastomosis. The lower clamp should be removed during this irrigation in order to provide egress for the

Fig. 5.—Postoperative arteriogram showing constriction of lower anastomosis due to vein graft having been inverted into popliteal artery.

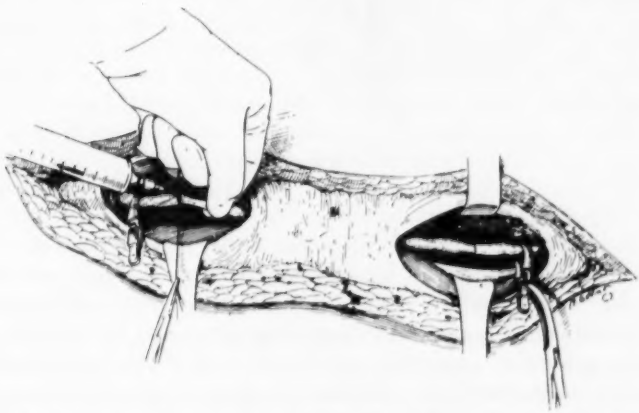

Fig. 6.—Graft in place, lower anastomosis completed, upper anastomosis half completed, saline irrigation used to flush graft and test lower anastomosis.

irrigation (Fig. 6). At this point 50 mg. of heparin in 10 cc. of saline is injected after the saline injection and is trapped in the graft by a bulldog clamp near its upper end.

After the upper anastomosis has thus been completed in a fashion similar to the lower, the upper and lower clamps are removed simultaneously. The graft is observed for 15 minutes (Fig. 7). Most points of leakage do not need stitching and are controlled by gentle pressure, but one must avoid too vigorous pressure which may constrict the segment and cause thrombosis.

Fig. 7.—Completed graft.

Preliminary Sympathectomy.—Four of the 10 extremities had had previous lumbar sympathectomies. They had been done earlier in an attempt to relieve the patients' symptoms before reconstruction was considered. Lumbar sympathectomy does not add to the therapeutic objective which the reconstructive operation is seeking. Of the four patients whose grafts later obliterated, two of them had had a previous sympathectomy, one had not. And, since at the time of occlusion there was no deterioration of the limb circulation over the prereconstruction status in any of them, we did not feel that in the one case without sympathectomy the failure to do sympathectomy prior to the reconstruction had been a mistake in judgment.

By-Passing of Long Femoral Segments.—It has been evident that the greater length of superficial femoral artery by-passed, the stronger the upper pulse will be and, in general, the better the condition of the upper artery at the anastomotic site.

These conditions tend to make for a more successful anastomosis, and, due to the fact that there is less sclerotic artery remaining in the main-stem arterial channel to the limb, the changes of later thrombosis outside the graft are theoretically less.

Free Division of Collaterals.—It is important, particularly in the popliteal space, to divide all branches, the liberation of which will help to provide free mobility of the popliteal artery so that the anastomosis can be done under proper exposure. No deleterious effects have occurred in this group from dividing collaterals, even in the patients whose grafts later closed. It must be added, however, that only the smaller branches of the femoral arteries are referred to. The deep femoral artery, for instance, must obviously not be interfered with.

Avoidance of Torsion in the Graft.—Any degree of torsion of the graft should be avoided. Experience with one case in which the graft had to be replaced because a 90-degree twist had been inadvertently installed in it at the first suture has emphasized the point in our minds. A situation similar to an intestinal volvulus resulted when the graft was distended with blood, an almost total obstruction occurring at the site of the torsion.

Allowing Clamps to Remain in Place Until Both Anastomoses Are Completed.—Allowing blood into the graft prior to the completion of both anastomoses caused immediate thrombosis and the necessity of repeating an anastomosis after removal of the clot in two instances. It has therefore been our experience that it is well to avoid the creation of an arteriovenous fistula by the initial anastomosis of the lower end of the saphenous vein to the upper cut stump of the artery, allowing the proximal end of the saphenous vein to remain attached, as has been recommended by some. The reapplication of clamps in order to repair a minor leak in either anastomosis is also dangerous with respect to fibrin formation.

Postoperative Considerations.—Heparin has not been used postoperatively, although a case for it theoretically could be made in patients who have had a thromboendarterectomy in addition to the graft. Postoperative hypotension should be strenuously avoided. Examination of the lower extremity postoperatively should be done every hour during the first eight hours. A warm foot and increased oscillations in the calf are to be expected. The pedal pulses may appear slowly. If the foot is cold and the oscillations are not increased, then reoperation should be done at once. Reoperation has been necessary two times in the 10 cases reported. In one case, the graft was found to be clotted; in the other the diagnosis was faulty and the graft was not clotted. The one which was clotted was successfully handled.

RESULTS

Of the 10 operations (the 2 instances of early reoperation are counted as part of the original operation), there were 9 in which immediate results were considered good, and 1 in which closure of the graft occurred within a few hours after placement. Of these nine, there were six in which the arteries have since closed. In five the closure was in the graft itself, and in one in the iliac artery above due to progression of arteriosclerosis. The arteries remained patent prior to closure for 2 months in two cases, 3 months in two cases, 6 months in one case, and 10 months in one case. Three grafts are still patent, at 14 months, 10 months, and 6 months, respectively.

In the six instances of closure of the graft (the one closure in the adjacent artery not being considered), possible technical reasons can be adduced in three. These

were arteriosclerotic constriction of the iliac artery above causing poor flow at the upper anastomosis in one, technical constriction of the upper anastomosis in one, and stretching of an autogenous femoral vein graft to the extent of 2 additional centimeters in a third. In the three remaining instances of graft closure, no possible technical cause could be assigned.

The types of graft used in the cases in which closure occurred were homologous artery in two, autogenous vein in four. Of the homologous artery graft failures, one was due to misguided grafting at a point of poor flow below an area of arteriosclerotic narrowing, and the other, which occurred six months after placement, was due to no obvious cause.

CONCLUSIONS

The long-term patency of grafts to arteries obliterated by arteriosclerosis performed according to the technique described is insecure. It is possible that a series consisting of homologous arterial grafts will fare better than the group here described, which has consisted largely of autogenous saphenous veins. Our experience with arterial grafts is limited.

It is our opinion that the technique described is a useful method of short-term restoration of arterial continuity but cannot be relied upon to give long-term protection against the effects of arteriosclerosis obliterans.

SUMMARY

Experiences with arterial reconstruction by grafting in 10 extremities disabled by arteriosclerotic obliterans are reported.

In nine instances an immediate successful result was obtained. Of these nine, there were five in which the grafts closed by thrombosis between 2 and 10 months postoperatively, and a seventh limb has shown occlusion of the main arterial stem at a point above the graft.

Detailed points of techniques described are useful primarily in cases in which short-term restoration of arterial continuity is indicated.

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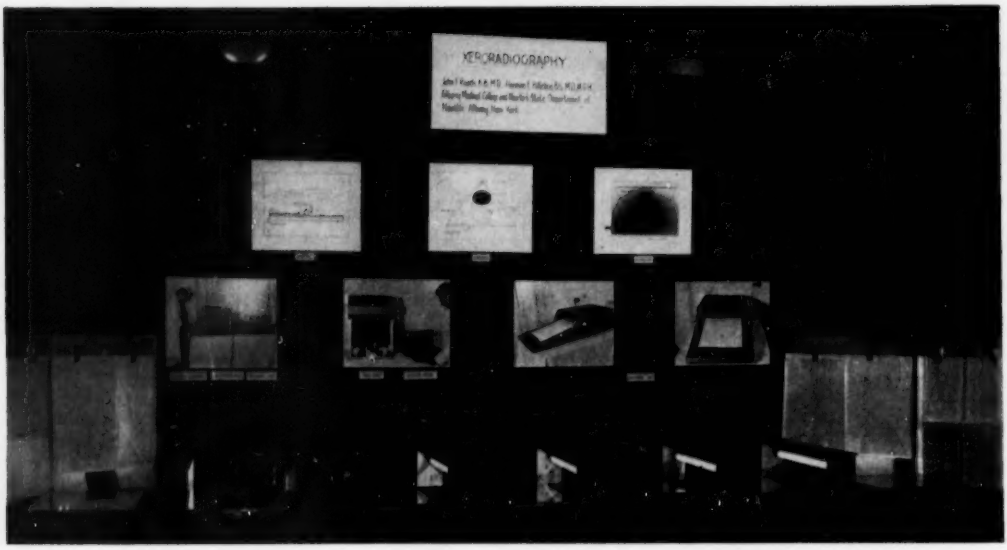

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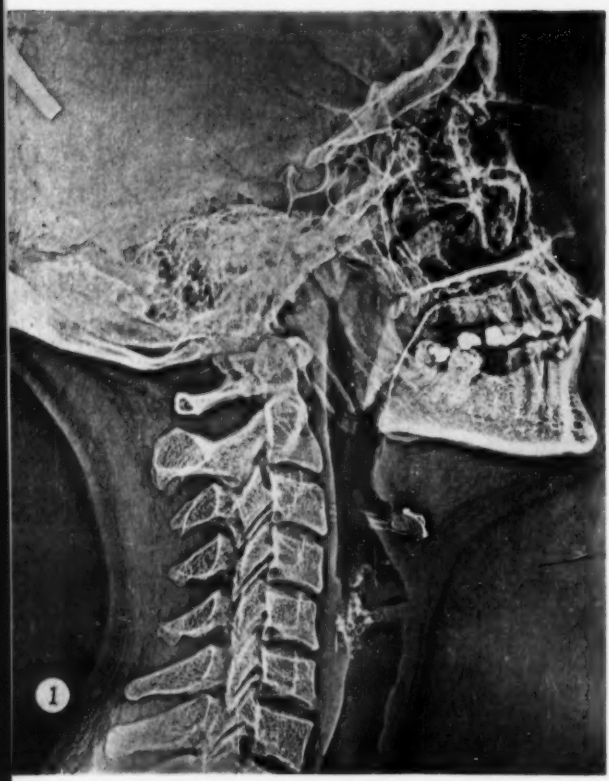
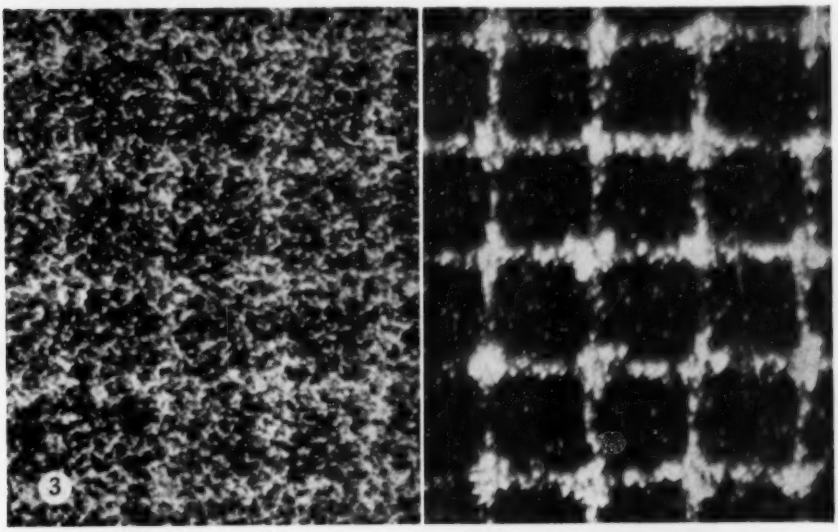


XERORADIOGRAPHY is a new medium for recording roentgen images. Unlike conventional film, it uses no solution of any sort and thereby derives its name from the Greek word "xeros," meaning dry. It is photoelectric in nature rather than photochemical. The basic element in the process is a metallic plate coated with a thin layer of selenium, a semiconductor. In practice, a homogeneous electric charge is sprayed on the surface of the selenium. The plate is then exposed to x-rays in the same fashion and with the same equipment one would utilize if ordinary x-ray film were to be employed. The x-rays which pass through the subject and strike the plate selectively dissipate the electric charge on the selenium. This results in the production of a latent electrostatic image. The image can be made visible by dusting the surface of the selenium with finely divided powder granules which adhere to the selenium in accordance with the pattern of the electrostatic charge.

The image obtained (Fig. 1) has much the same appearance as a standard x-ray film, except that detail and contrast gradation are superior to that found in conventional x-ray film (Fig. 3 and Fig. 4).

After the image is viewed, a permanent record is made by electrostatic or adhesive transfer of the powder to a piece of paper. The plate is then cleaned by brushing, after which it is ready for reuse. Figure 2 is a photograph of the image of a shoulder on a plate that has been used 2,500 times.

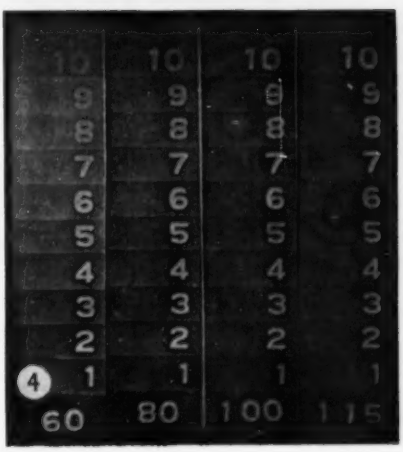
Figure 3 demonstrates the resolving power of a xeroradiographic plate in

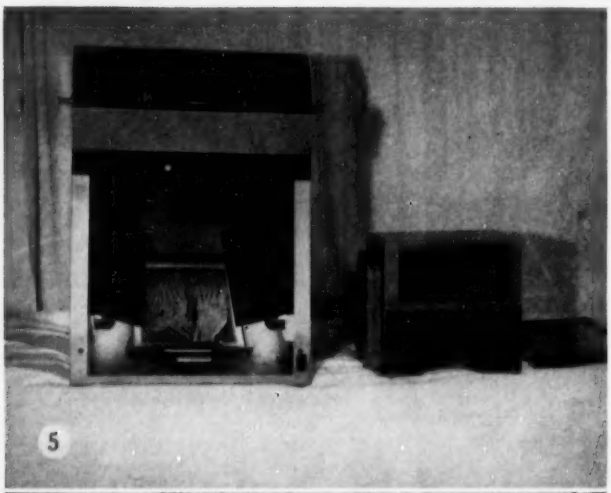


comparison with x-ray film. The illustrations are photomicrographs of the roentgen images of a very fine bronze wire screen (180 openings per linear inch); on the left as seen on x-ray film (without screens), and on the right, a xeroradiographic plate.

Figure 4 is a photograph of xeroradiographs of an aluminum step wedge done at 60, 80, 100 and 115 kv. It demonstrates the very long scale inherent in xeroradiographs.

Figures 5 and 6 are photographs of the equipment used in xeroradiography. Figure 5 includes plate-charging and





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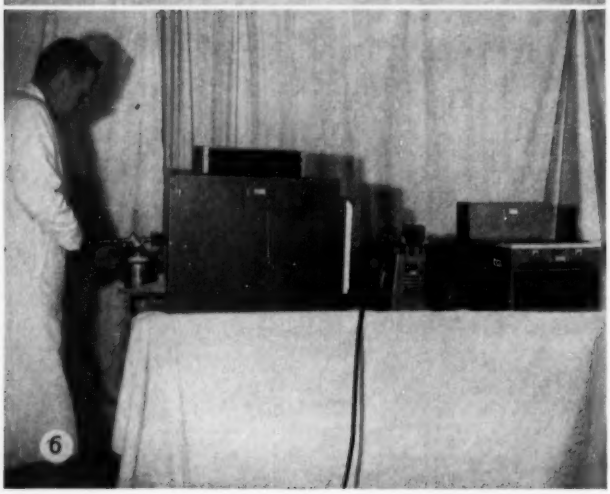

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powdering units, and Figure 6 shows the viewing and cleaning apparatus.

The time required to produce a xeroradiograph is very brief. The plate-charging time is 10 seconds. The exposure is much the same as conventional filming, a fraction of a second to, perhaps, five seconds. The dusting period is 20 seconds. It is, therefore, easily possible to have a completed xeroradiograph ready for viewing and interpretation within 30 seconds after the x-ray exposure is completed.

Professor of Radiology, Albany Medical College and Radiologist in Chief, Albany Hospital (J. F. R.), and Professor of Preventive Medicine, Albany Medical College and Commissioner, State Department of Health, State of New York (H. E. H.).

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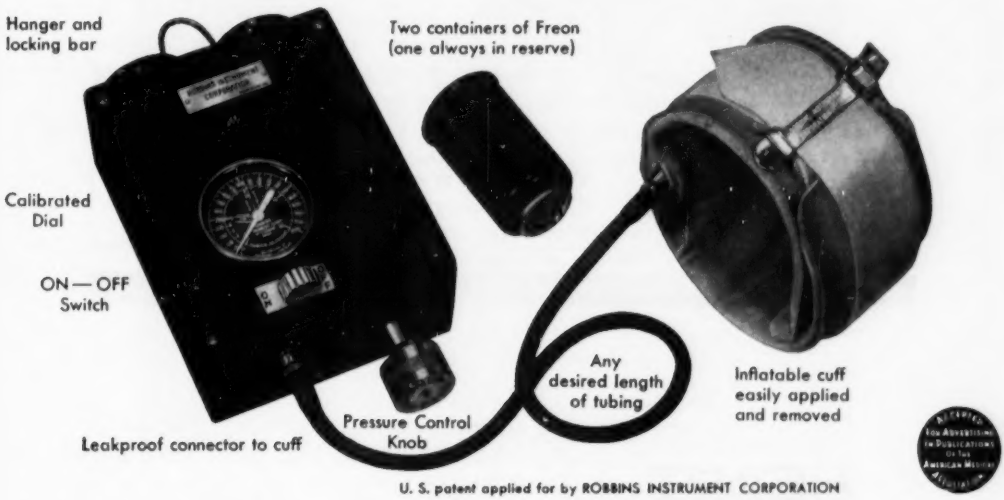
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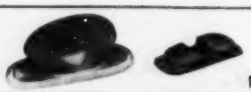

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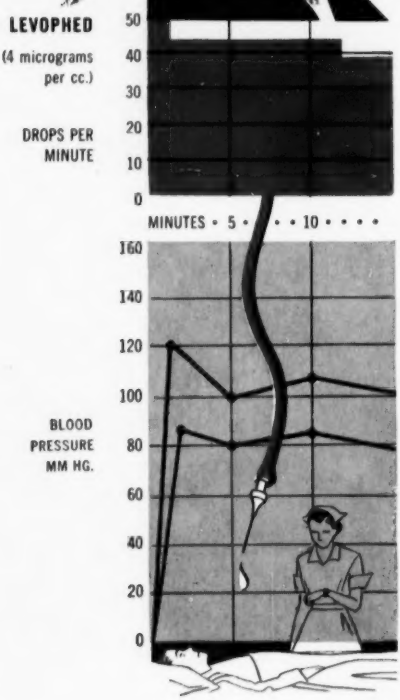

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